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China Report

SCIENCE AND TECHNOLOGY

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CHINA REPORT
SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

EFFECTS OF S&T REFORM ON CONDITIONS IN CHINA EXPLORED

Hong Kong LIAOWANG [OUTLOOK] in Chinese No 24 16 June 86 pp 15-16

[Article by Zhou Daping [0719 1129 1627]: "Reform of the Chinese Science and Technology System Has Brought Pleasing Changes"]

[Text] The reform of the Chinese science and technology system has greatly hastened the rapid and broad application of scientific and technical achievements in production, and has opened up an even more vast territory in which scientists and technicians can function positively in economic construction. This reform is playing an ever more obvious role in freeing up production forces and promoting economic and social developments.

Opening Up the Technology Markets

The "Resolution Regarding Restructuring of the Science and Technology System" issued by the Central Committee in March 1985 fully affirms the commercialization of technical commodities and the opening of technology markets that has evolved in recent years. The dissemination of Chinese scientific and technical commodities has always been through allocation by government departments and through uncompensated transfer of rights according to subordinate relations. This kind of administrative method is not conducive to the rapid and broad application of scientific and technical achievements in production. With development of the commercial economy, various technology trade activities have appeared in succession. More and more small and medium enterprises have realized the value of knowledge and the function of talent, and they have not been afraid to spend the money for technology, nor have they been put off by the seeking and employment of talent. Therefore, scientific and technical achievements have gotten away from the restraints of traditional management models, and have entered the realm of commodity circulation to become "hot items" unable to meet demand. In this way, technology markets, that use economic levers to accomplish the transfer of rights to scientific and technical commodities through direct discussions between buyers and sellers, have rapidly developed throughout the country. By the end of 1985, there were more than 5,000 organizations undertaking technology trade.

Science research units have obtained research projects from the technology markets, and have also obtained bases from which to carry out intermediate experiments, which has quickened the industrial development of technologies;

production units have obtained advanced functional technical commodities from the technology markets that have strengthened their capacities for absorption of technology. During the period of the Sixth 5-Year Plan (1981-1985), nearly half of the scientific and technical achievements of the Chinese Academy of Agricultural Science have been used in actual production, which is inseparable from the following point: the 33 affiliated institutes (laboratories) established research and production associations with 10 prefectural and municipal town and township enterprises. There have now been more than 9,800 associations of this type established in China.

The development of the technology markets has greatly improved the rate of application for scientific and technical achievements. Looking at the first technology market in the country, the Wuhan Municipal Technology Market, as an example, the rate of application of scientific and technical achievements in 1981 was only 10 percent, but by 1984 had grown to be more than 60 percent. The total volume of technology transactions in technology markets throughout the country have abruptly increased from the 1.5 million yuan of 1983 to the more than 2.3 billion yuan of 1985.

The constant flow of scientific and technical commodities into the fields of production is certain to stimulate the reasonable movement of personnel and the development of intellect. In the past few years, Hebei Province has attracted scientists and technicians by the thousands from the science and technology talent rich Beijing-Tianjin area to cooperate in developing technologies with provincial enterprises, which has vigorously advanced economic development throughout the province.

It should be said that as science research units serve society more, the economic results obtained therefrom are greater, and the capacity for undertaking redevelopment is therefore stronger. This is also of use in the establishment of mechanisms by which the technology development of research units and colleges and universities can recover their investments. In 1985, net income for more than 40 colleges and universities from technology trade was 80 million yuan, equivalent to 30-40 percent of the science research operating expenses for these institutions. This excellent environment for self development established by science research units is a prerequisite condition for reforming the existing science and technology allocation system.

China's technology markets are new things that will continue to advance and improve in the process of development. In March of this year, the State Science and Technology Commission Chairman, Song Jian, spoke at the National Technology Market Working Conference, where he said, "The goal of the reform is to create an environment that will allow research units and research personnel to have direct contact and relations with society. This is a crucial measure for the reform." At present, the State Science and Technology Commission is enhancing coordination, leadership, and management of technology markets, and has as well begun formulating relevant associated rules and regulations. This will allow the technology markets to better serve as bridges and links in promoting the integration of science and technology with the economy.

The Academy of Sciences Opens Up Some Laboratories

The socialization of science research units is a tendency in the development of science and technology in China. For the Chinese Academy of Sciences to open up laboratories allows them to be shared by scientists throughout the country and to receive the benefits in which objects are made the most of and people realize their talents. This measure itself shows the excellent beginning for this trend.

In the past, because of the closed form of the science research system in which "departments owned all and individuals worked for the government," it was even hard for research personnel to transfer, so the rate of usage for experimental instruments and equipment was low. In August 1985 the Chinese Academy of Sciences faced up to this abuse and in a planned way opened some institutes and laboratories to the rest of the country. On the one hand, this provides scientists and technicians not affiliated with the Chinese Academy of Sciences with the most advanced instruments and equipment. On the other hand, their constant infusion of new academic ideas, thinking, and research directions enlarges the scope of possibilities for cooperation in research. Consequently, this can promote exchanges among the sciences and also has great significance for the development of basic science.

Before the structural analysis laboratory of the Chinese University of Science and Technology was opened to the public, many sophisticated instruments and equipment were only used a few times a year. Since its opening up, they are in operation nearly 24 hours a day all year long. Some developed countries have obtained noteworthy results in research on fungi that are in close contact with human life, while research in this area in China has progressed quite slowly. The fungi laboratory of the Chinese Academy of Sciences' Institute of Microbiology has the only fungi incubator in China, and before the opening up it was difficult to realize its potential, nor was the enthusiasm of scientists and technicians given full rein. But now, after opening up the fungi incubator, our level of scholastic research has improved.

Opening up the laboratories brings a new strength to scientific and technical exchanges and cooperation between the scientific academies and the higher institutions and industries, which has quickened the pace at which scientific and technical achievements are disseminated and applied. The Chinese higher institutions are a science research contingent of nearly 400,000 that is of multiple disciplines and multiple levels. The amount of transactions in the transfer of rights to technology was more 126 million yuan in 1985.

The opening of the laboratories by the Academy of Sciences has been greeted by universal welcome in science circles. Among the 360 projects in the 17 laboratories of the mathematics institute and the institute of theoretical physics that were the first to be opened, 70 percent are projects outside the institute or are in cooperation with the outside; among the more than 1,200 scientists and technicians participating in research on these projects, 60 percent are specialists and scholars outside the institutes. Currently, the Academy of Sciences is setting up and perfecting management methods for science. It is estimated that not long from now there will be even more institutes and laboratories that will be opened to scientists within this country, and some will be opened to those abroad as well.

The Rise of "Spark Plans" and of the Rural Economy

In recent years, one of the major indications of the tremendous changes in the rural economy has been the rise of town and township enterprises as a new force. At present, town and township enterprises employ a rural labor force of 60 million and have continued to support agriculture in the areas of funding, agricultural technology, and mechanized power. Output value of town and township enterprises has reached 248.1 billion yuan, approaching 20 percent of the national industrial and agricultural gross output value. Premier Zhao Ziyang has pointed out that "it will not be acceptable to transform agricultural structures without developing town and township enterprises, and there will be no future for the transformation of town and township enterprises without relying upon science and technology." The "spark plans" were born under just these conditions and are a grand blueprint for the gradual arming of the rural economy with modern science and technology.

Five years ago, while organizing research by the State Science and Technology Commission into developing the Taihang mountainous area, the "sparks and tinder" that are science and technology were brought there for the first time. Today, the rural economy of the Taihang mountainous region continues to flourish, per capita income having grown more than four times over that of 1981. Lingchuan County, Shanxi, located at the top of the Taihang mountains, depended for a long time upon the finances of the state to supplement its living. Since the introduction of science and technology, things have prospered year after year until the gross output value for the county's town and township enterprises broke through the hundred million yuan mark to create the highest level in the history of that county.

The prosperity of China cannot be separate from the countryside, while the prosperity of the countryside depends upon continued development of town and township enterprises and continued strengthening of rural science and technology contingents. In the understanding of the leading group of the State Science and Technology rural survey, some of the key projects in contemporary agricultural production still await resolution, and the technical production management standards of town and township enterprises need to be improved. The existing 14 million strong scientific and technical contingent in this country, in control of the great majority of scientific and technical information and achievements, has the complete capacity to serve the increased agricultural production and the transformation and improvement of town and township enterprises. During the period of the "Seventh 5-Year Plan," in meeting the requirements of the "spark plans," 100 kinds of complete sets of technologies and equipment will be developed for town and township enterprises throughout the country, at the same time as large-scale production is arranged; entire techniques and technologies, management rules and regulations, product designs, and methods for quality control will be provided for 500 model technology enterprises among them; and more than 1 million people will be trained in a specialist technology. It can be presumed that on behalf of the integration of science and technology with the rural economy, the "spark plans" will create many valuable experiences that are in keeping with the Chinese national situation.

12586
CSO: 4008/2117

EMPHASIS ON MILITARY TO CIVILIAN TRANSFER URGED

Xian SHAANXI RIBAO in Chinese 4 Aug 86 p 2

[Report by Xu Xing [1776 5887]: "Vigorously Adapt to the Shift in Strategy for National Defense Science and Technology Industries"]

[Text] In accordance with scientific decisions regarding international and domestic trends, the central authorities have resolutely adjusted the plans of this country for the building of national defense. Requiring the national defense science and technology industry to make major strategic changes regarding service, the military and industry system, the guiding ideology for work, and management will take the major strength of national defense science and technology from the "little universe" of military-industrial production to the main battlefield of the national economic construction. It will serve the overall building toward modernization, and will allow the national defense science and technology industrial contingent to become the main army and strikeforce for the drive toward modernization. This wise decision by the central authorities has a far-reaching historical significance, as well as great practical significance.

How are we to adapt to this historical change? In my opinion:

We must first proceed from the general situation of national construction and correctly recognize the situation confronting national defense industries. We have reduced production tasking of military goods to a great degree. This was to comply with the general situation regarding economic construction, and was at the same time to better promote the modernization of national defense. We must be certain to realize this point, that from the point of view of guiding ideology, we have turned from a purely defense orientation to one that serves the four drives toward modernization.

Establishing joint military civilian enterprises is a long term strategic principle, definitely not just for expediency, and is the second problem of recognition about which we must be clear. In recent years, the steps some of the military industrial enterprises in this province have taken toward shifting from the military to the civilian have not been great ones. One of the main reasons has been that understanding of this problem has been insufficient, that there have been wait-and-see attitudes and a willingness to leave to chance, and a hope that one day we would again deal with purely military commodities. Many enterprises are still used to "tasking by the government, materials provided by the government, products sold by the government, profit or loss taken care of by the government," which is certainly not appropriate to the shift toward producing civilian goods. We have now made the decision to make a big and quick shift, which is the current trend and for which there can be no hesitation. Only if military industrial enterprises can be aware of this historical trend and can strive for the autonomy to develop will they be able to develop their potential advantages, and will they have a broader field in which to deploy their arms.

Third, we must improve knowledge of the new joint military civilian systems. What do we mean by joint military civilian types? Leading comrades of the central authorities have pointed out that joint military civilian enterprises are new types of dual nature systems that require military industrial enterprises structurally to take on both military goods and civilian goods gradually. The principle of production for enterprises, rules for construction, and production line facilities should all be managed in accordance with this thinking. Only if this problem is clear can military industrial enterprises be fully free to operate, can they have long term planning, and can they have a new vitality. Some military industrial enterprises have long lacked vitality, an important factor of which is that there has been no true understanding of the far-reaching significance of the joint military industrial format.

The key to realizing this change in strategy regarding national defense science and technology industries is in the change in structure. National defense science and technology industries are very important social production forces, but the current structure still hinders the development of production forces, obstructing the fulfillment of the advantages and potential of national defense science and technology industries. The situation requires that we make use of restructuring and a heightened spirit to bring big changes to the realization of this system. It requires that we change the military industrial structure to a vital structure, and that we allow the truly powerful national defense science and technology industrial contingent to move toward the broader world of our drive toward modernization, to make contributions toward the prosperity of the national economy.

To establish this new structure that is an association of the military and civilian, we must proceed from the two aspects that are the industry as a whole and the enterprises themselves. Within the enterprise, there should be an adjustment of commodity structures, a shift from pure production of military goods to "an integration of the military with the civilian, with a focus on the civilian." We should reasonably arrange for proportional relations between military and civilian goods, should learn how to accomplish the two capabilities that are the military and the civilian, should be able to have both mainstay military commodities and also mainstay civilian commodities, all to constitute a situation of self sufficiency for both military and civilian goods, where they develop in coordination. At the same time, we must solidify establishment of the concept of a commodity economy to truly realize the change from a provisional model to an operational one, and must enhance the sense of urgency for marketplace competition. In the past military industrial enterprises were generally of the closed, provisional type. They produced few goods over a long term and at high cost, and had little competitive capacity. Only if military industrial enterprises can quickly implement open, operational modes can they completely realize their own technical and equipment advantages. Only then will they enhance their competitive capacities and stand on firm ground. In addition, under the prerequisite of finishing their tasking for military goods, they will establish a rather complete civilian goods production and science research system, which can fundamentally achieve independent development of various new kinds of civilian goods, earnestly accomplishing a secondary development of military goods and a shift toward civilian use industries and civilian use commodities.

Another important aspect to the system restructuring is a streamlining of government and a release of authority to the enterprises. The planned and gradual release of authority from the military and industrial enterprises to the local level is a major strategic measure by which to implement the shift from military industrial enterprises to joint military and civilian models. Only by freeing them up with equal conditions for competition can enterprises be invigorated, and can the preservation of the military while shifting to the civilian have an exuberant vitality.

Shaanxi Province is one of the provinces in which national defense science and technology enterprises are rather concentrated. Since the 3d Plenary of the 11th CPC Central Committee, the development of military industrial enterprises into production of civilian goods has had a certain success. But overall, that development has not been an ideal one, and the steps toward changing to joint military civilian models have not been great, still quite far from the demands of the party Central Committee.

The strategic shift toward implementation of a joint military civilian system will be effected in many areas of effort, and will be realized in practical actions. To this end, we must pay special attention to the following tasks:

1. Enterprises must greatly enhance new product development and technology development in accordance with economic development strategies in order to hasten the pace of shifting from the military to the civilian. At the same time as we control the development of military goods, development of civilian goods must pay close attention to the major commodities arranged for by the state and the province. Each enterprise should integrate its own characteristics to take on one or more "mainstay commodities."

2. Focusing on the development of civilian goods, we should earnestly deal with the technology transformation of the military civilian joint models. In the development of civilian goods, we must select those commodities accurately and keep to higher starting points, paying special attention to economic batch quantities. For those civilian goods that do not currently constitute economic batch quantities, attention should be paid to association, matching, transformation, and management to more quickly attain batch quantities. Development of civilian goods and technology transformation must make full use of production conditions currently existing in military industrial enterprises, must make full use of advantages, exploit potential, and constitute new production capacities.

3. For well known goods newly on sale, and especially for products that can be exported and earn foreign exchange and that can replace imported goods, arrange for military industrial enterprises and for civilian enterprises to undertake joint development, joint testing, and joint manufacturing, to gradually form a new type of economically integrated organization, and to develop a group of enterprise associations or enterprise groups.

4. Vigorously develop technical services and technical business activities to hasten the shift from military industrial technology to the civilian. In accordance with the "spark plans" as formulated by the state, pay close attention to developing a group of "short, even, and quick" projects to provide new practical technology for regional small to medium enterprises and to promote technical advances.

5. Pay very close attention to the link of circulation, strengthen marketing, "use marketing to stimulate production, production to create marketing," and establish a concept of a socialist planned commodity economy. This is an important link for the development of civilian goods production. Military industrial enterprises must take care of this link through the integration of military with civilian to allow commodities to be "known by the people, used by the people, and enjoyed by the people."

6. Consider the entrance of civilian goods into the international marketplace as a key direction for developing the advantages of military civilian enterprises, which will gradually constitute a base by which some individual products can be exported and earn foreign currency.

7. Pay close attention to the restructuring of systems internal to medium and large enterprises, create small units for accounting, clarify the economic responsibility systems, and make full use of subjective mobility to allow them to operate independently and be responsible for their own profits and losses, and to strengthen the economic and operational vitality of the factories.

12586
CSO: 4008/2126

MILITARY SCIENCE ACADEMY OPENS RESEARCH TO DOMESTIC UNITS

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 22 Aug 86 p 4

[Report by Bao Shixiu [7637 0013 0208] and Liu Guanxian [0491 7070 6343]: "Our Military Science Academy Has Begun Open Research"]

[Text] The PLA Military Science Academy Director Zheng Wenhan [6774 2429 5060] and Political Commissar Wang Chenghan [3769 6134 3352] recently let it be known that hereafter the Military Science Academy would not only be open to the outside, establishing relations with domestic research units, but also would enthusiastically create conditions by which to establish relations with foreign military units and relevant scholastic organizations and scholars.

The Chinese PLA Military Science Academy was founded in March 1958, and the first director and concurrent political commissar was Marshal Ye Jianying. The Military Science Academy has primarily been engaged in research in the areas of military theory, military ideology, strategy, campaigns, tactics, military systems, military history, foreign military studies, and troop political work, making use of automated equipment for battle operations research and analysis, being responsible for the writing and revision of relevant regulations and ordinances, and for editing the "Chinese Military Encyclopedia" and other reference books. This academy has paid special attention to national defense strategies of development and practical research into relevant troop establishment and problems of warfare. It has provided the Military Commission of the Central Committee and the PLA General Political Department with suggestions and advice regarding decision making.

For some time now, the Military Science Academy has adopted a closed mode for research. As far as the majority of people outside the military and both in and out of this country have been concerned, the Military Science Academy has been unknown. These two officials feel that doing research in this modern situation requires enhancement of lateral relations and the opening up of research. The development of military science must be oriented to what is modern, to the world, and to the future. In adopting a closed form of research, we cannot generate advanced military thinking, and it is insufficient for responding to the challenge of future conflicts to traditional battle theories. Over the past few years, the Military Science Academy has done some work in the area of establishing relations with the outside. The first thing has been to stress scholastic exchanges. This year, they have held the "Academic Conference on National Defense Strategy and Systems Engineering in the Year 2000," and will join with related units to hold academic conferences on Chinese modern military history, to commemorate the 50th anniversary of the Long March victory by the Red Army, and on troop management. Then, it will invite specialists and scholars from within and outside the military to evaluate military and scholastic end products. Third, it will strengthen lateral relations. This year, it has already discussed jointly with various related academic and research sectors planning and coordinating work for military scholastic research throughout the military. It has also sent out survey groups to all army strength areas and relevant institutions to understand the situation regarding academic research.

They were also happy to discuss the open-door policy of economic construction in this country, which created advantageous conditions for opening up military science studies. We want to make full use of the current excellent conditions and excellent opportunities to gradually establish connections with foreign military research organizations and their specialists and scholars, whereby to undertake far-reaching scholastic exchanges. The Military Science Academy has the ability to participate in various relevant scholastic activities internationally.

12586
CSO: 4008/2126

CAS SCIENTISTS TO PARTICIPATE IN POLICY MAKING

HK150242 Beijing CHINA DAILY in English 15 Sep 86 p 3

[Article by staff reporter]

[Text] The Chinese Academy of Sciences [CAS] will be more active in organizing China's top scientists to contribute to the democratic and scientific policy-making sought by the Chinese leadership, said Yan Dongsheng, vice president of the academy, at a meeting of the Technical Science Academic Division that opened yesterday.

He said that as the members of the academy are the most outstanding scientists and experts in China, they should participate in state policy-making as special counsellors.

So, for the first time, over 90 well-known academics from different fields, 40 government officials and 20 technical experts from local enterprises gathered together to compare notes on the current social, economic and scientific developments.

"We've invited officials from major government departments to report and join discussions at the meeting. We believe this will help our scientists know more about the level and needs of national development," Yan said.

According to Shi Changxu, director of the technical science division, the academy will propose four main subjects for its members to deliberate on and provide advice for the government.

The subjects include the allocation and utilization of resources; development of infrastructure; high-tech research, urban and rural construction and environmental protection.

CAS expects the scientists will form special subject groups and raise their research projects during the four days of reports and discussions. After the meeting, the groups will set out on study and field inspections.

"We hope the scientists will bring out some valuable reports in a couple of years. Because we are at an experimental stage so far, we'll focus on a few subjects at present. In future, we'll expand the counselling into more fields," Yan said.

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CSO: 4010/2002

TELEVISION TO BE POPULARIZED IN RURAL AREAS

OW240726 Beijing XINHUA in English 0727 GMT 24 Aug 86

[Text] Harbin, 24 Aug (XINHUA)--The electronics Industry Ministry calls for rural China to popularize television in the near future, said an official at a meeting on television popularization here today.

Five measures, adopted at the meeting, are as follows:

--Put the market emphasis on cheaper black-and-white television sets;

--supply complete sets of television equipment including satellite television receivers, relay receiver- transmitters and public aerials;

--encourage group sales;

--enhance maintenance service; and

--lower the selling price.

Increased domestic television production and improved living standards create a favorable condition for television popularization in the countryside. However, shortage of famous-brand tv sets and poor maintenance service hinder sales.

China has an annual production of 16 million tv sets. Demand for black-and-white tv sets has been diminished among urban residents who are turning to color models. The rural areas, where, on average, each 100 households possess 11.8 tv sets, have a large potential market, said the official.

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CSO: 4010/1002

TECHNOLOGY TRANSFER BY MINISTRY OF AEROSPACE INDUSTRY

Beijing BEIJING KEJIBAO in Chinese 18 Jul 86 p 2

[Article by Jin Yan [6855 1484]; first paragraph is source supplied introduction]

[Text] Editor's note: The No 31 Institute of the Ministry of Aerospace Industry has established a policy of technology transfer for the benefit of the general public rather than just to enhance their own profits. They have implemented a plan where technologies are transferred to the receiving organizations based on geographic regions, orders received, and priorities. By temporarily sacrificing their own interests, the state will benefit in the long run because most receiving organizations can enjoy healthy growth. If more organizations will follow the example of the No 31 Institute, the resulting social and economic benefits can be substantial.

The No 31 Research Institute of the Ministry of Aerospace Industry has received favorable comments from technology-receiving organizations for their far-sighted policy of not seeking only near-term profits and for their innovative approaches in technology transfer.

In 1984, this Institute developed the new technology,"producing asphalt using cotton-seed nigre", which was quickly transferred and produced visible economic benefits. However, because of their failure to consider the distribution of customer demand, the price of raw material rose sharply, and many new businesses were forced to close down. Last July, the Institute developed another new technology--producing pure alkali, which could be readily adopted by medium and small enterprises. But after receiving orders from several hundred customers around the country, they decided to carefully review the overall interests of their customers in addition to their own economic benefits, and implemented the following measures.

Based on the data provided by the raw materials survey bureau, they concentrated the development in regions with ample supply of raw materials while at the same time taking into consideration the rationality of the distribution process. For customers located in a region where raw materials are rare, they would suggest that this technology not be accepted. For regions where the availability of raw materials is uncertain, the decision of technology transfer would be postponed until a detailed survey has been conducted.

The Institute has developed a number of additional production technologies which are currently being transferred. Again they insist on the policy of "customers first", so that small enterprises in towns and villages can healthy growth.

3012/12948
CSO: 4008/96

NATIONAL DEVELOPMENTS

PLANS SOLIDIFYING FOR S&T ALLOCATION REFORM

Beijing RENMIN RIBAO in Chinese 15 Aug 86 p 2

[Report by Zhuo Pei [0587 1014 2837]: "Full Scale Reform of Science Research Operating Expenses Is Readied"]

[Text] Concerned areas have been notified that work by all departments of the State Council on restructuring of science research operating expenses is now ready. As of now, indexes for science research operating expenses from 53 departments have been transferred from the Ministry of Finance to management by the State Science and Technology Commission. Categorization by research organizations affiliated with the departments has been basically completed, and the 1986 budget for science research expenses at the Central Committee level has been promulgated in accordance with the new management channels. This reform has also begun to a certain degree within all provinces, municipalities, and autonomous regions.

The reform in research operating expenses is a component part of the entire restructuring of the science and technology allocation system. In January of this year, based on the spirit of the resolution by the Central Committee regarding restructuring of the science and technology system, the State Council has published the provisional regulations for the management of science and technology allocations. It has been determined that there will be categorical management of research organizations in accordance with differing activities and characteristics, whereby expense management methods such as the contract system, the fund system, and the responsibility system are each adopted. It has been decided at the same time that beginning this year the science research operating expenses that had formerly been allocated to research organizations through responsible departments according to number of personnel would be redesignated to be under the uniform management of the State Science and Technology Commission.

On the basis of experiences obtained through restructuring of the science research operating expenses of all departments of the State Council, the Office of Culture and Education of the Ministry of Finance and the Bureau of Regulations of the State Science and Technology Commission have recently held a conference on the restructuring of national and local science research operating expenses, where it was decided to hasten the progress of this restructuring in the provinces, municipalities, and autonomous regions.

Science and technology contingents from the provinces, municipalities, and autonomous regions occupy an important position among the structures of science and technology strength in this country, among which scientists and technicians account for more than one-half and operating expenses are nearly one-third of allocations for national science research operating expenses. At the same time, this contingent is also a most vital force in catering to the economy. Among the 1,500 science research organizations that have instituted contract systems and the 317 science research organizations that have become economically independent, those at the provincial, municipal, or autonomous region level occupy 87.7 percent. Therefore, it is recognized in relevant areas that to hasten the progress of restructuring science research operating expenses for provinces, municipalities, and autonomous regions, full scale initiation of the restructuring of science research operating expense allocation, and even the development of the situation regarding restructuring of the entire science and technology system, will be a powerful incentive.

Zeng Xianlin [2582 2009 2651], deputy director of the State Science and Technology Commission and deputy director of the State Economics Commission, spoke at the conference, requesting that each region come up with a plan for restructuring as soon as possible, that they formulate working plans, and that by the second half of the year they finish solidifying this work, so that there will be a good foundation for full scale categorical management next year. At the conference, some provincial, municipal, and autonomous region comrades explained their situations regarding relevant restructuring preparations.

12586
CSO: 4008/2126

MUCH OF CHINESE S&T CALLED 'STATE OF THE ART'

Hong Kong WEN WEI PO in Chinese 12 Aug 86 p 3

[Article by Jie Ling [0267 7227]]

[Text] The Minister of China's Nuclear Industry, Jiang Xinxiong, admitted that the published report on the safety problem of the Daya Bay nuclear power plant only addresses general issues, and does not contain sufficient details. For this reason, this Ministry is in the process of preparing a more comprehensive report which will discuss the safety problem in greater detail. This report will be made public as soon as it is completed.

This message was passed on by the Secretary of Public Affairs of the Hong Kong Scholars Association, Xu Shixiong (professor of biology at the Hong Kong University), during a news conference where he gave a report on the results of his recent visit to mainland China. According to Prof. Xu, Minister Jiang Xinxiong believes there will be little flexibility in changing the current plan to build the Daya Bay nuclear power plant; he did emphasize that the design of the power plant will meet the world's highest safety standards, and indicated that the project is now in the detail design phase.

Prof. Xu also said that during the meeting with Jiang Xinxiong, the visitors presented him with some foreign literature on nuclear power generation, and openly expressed the concerns of Hong Kong residents about the Daya Bay power plant.

Observations at the Satellite Launch Center

"At the invitation of the Chinese Education Commission, 15 members of the Scholars Association of Hong Kong spent 9 days (from 2 August to 10 August) on a tight-schedule tour where they visited several Chinese facilities including the Xichang Satellite Launch Center, Sichuan University, Changzhou City and the Chinese Institute of Nuclear Science. The visitors exchanged ideas with Chinese representatives on the relationship between higher education and social, industrial, and economic development. Such exchanges were one of the main objectives of this trip." With this introduction, Prof. Xu proceeded to describe the results of this tour.

This delegation was the first group of visitors from Hong Kong ever invited to tour the world-famous Xichang Satellite Launch Center. "The impression I got from touring the Center is that most of the equipment there is made in China. The Center is highly efficient; the militarized management system and the thorough inspection procedures are impressive," Prof. Xu said. This reflects China's serious attitude toward high-technology development.

"Later, we visited Sichuan University, which recently had received a loan from the United Nations to purchase research equipment for graduate students; this equipment is of higher quality than that available at the two Science Institutions in Hong Kong." Prof. Xu has a special interest in research facilities at universities and colleges.

Changzhou was one of the key stops on this tour because it represents a typical example of successful inland industrial reform. The successful reform of the economic system of Changzhou's industries was attributed to the fact that many local businesses had evolved from subsidiaries of past administrative offices into independent enterprises with authority to make their own decisions. Over the years, Changzhou has become a city of many individual businesses; it has established a free market system as well as a new system whereby economic coordination and economic growth of towns and villages in the county are stimulated by urban economic activities.

Exchanging Experience on Higher Education

"We have learned from this tour that China is paying a great deal of attention to the correlation between higher education and economic development." This was the feeling expressed by members of the delegation after listening to a report by the deputy director of the Chinese Education Commission, He Dongchang, on China's education reform, and after a meeting with members of China's Higher Education Society.

During the discussion, He Dongchang pointed out that there is a tendency for Chinese students to relax their attitude toward learning once they have entered college. Their approach to solve this problem is by tightening the requirements; they also try to develop the students' ability to conduct independent research, to analyze and solve problems, and to explore and create new things. In addition, courses in the areas of organization and management are emphasized and special programs have designed for students with exceptional capabilities.

In the spirit of academic exchange, members of the Scholars Association also discussed the status of Hong Kong's higher education and its future prospects, and offered suggestions on education reform.

Achievements of China's Nuclear Research

After a visit with the director of the Chinese Academy of Sciences, Lu Jiaxi, the Hong Kong delegates were given a tour of the Chinese Institute of Nuclear Science and an introduction by director Sun Zuxin. "We were given a tour of the heavy water reactor, the isotope product exhibit room, the isotope production line, the miniature reactor, and the serial accelerator. We were very impressed by the high level of technical capabilities and research activities at the Institute." Prof. Xu continued: "Over the past 30 years, the Institute has trained and delivered more than 3,000 nuclear scientists, engineers and specialists. Nuclear research has had a long history in China; through this tour we came to appreciate the rich experience and achievements of China's nuclear research."

In addition, the Institute also described for the delegation the status of the Qingshan Power Plant, and realizing that the safety issue of the power plant would be of particular interest, they presented the visitors with a collection of first-hand information on the subject.

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BEIJING AREA S&T SITUATION DISCUSSED

Beijing BEIJING KEJI BAO in Chinese 20 Jun 86 p 1

[Report by Liu Huanfa [0491 3562 4099]: "Directions for Science and Technology Within the City District"]

[Text] How is science and technology within the city limits of Beijing going to "face up," how is it going to develop? Comrade Gao Yuan [7559 0626], deputy director of the municipal science and technology commission, spoke on this problem at a science and technology working conference in the city's eastern district.

He pointed out that science and technology in the Beijing urban area will be appropriate to the spirit of the response of the central authorities regarding plans for development in Beijing. It will be limited to functions of the nation's capital, will cater to urban and economic construction and to economic management in Beijing Municipality, will serve the central authorities, will serve the residents of the city, and will resolve many of the inconveniences in the lives of residents. Therefore, we will not only resolve technical problems for small and medium enterprises within the city proper, but will solve technical problems in the realm of circulation. There is also work in culture and education, water and energy conservation, environmental protection and hygiene, public facilities, and in modern urban management, all of which are inseparable from science and technology.

Comrade Gao Yuan also pointed out that development of the city cannot be apart from technical advances, that development of urban science and technology cannot be divorced from personnel, and that to solve the technical problems just discussed we must make full use of the scientific and technical advantages of the nation's capital. We must bring in more technical achievements and personnel from the "5th" science and technology army of Beijing. And especially for some of the urban enterprises and neighborhood enterprises, if they are to consider greater development they must have personnel who have access to all kinds of scientific and technical knowledge, and they must take appropriate care of scientists and technicians who are brought in, for only if personnel are satisfied can they be used fully, and will the economic and social results be very great. If in this point there are no unhealthy tendencies, then it can be accomplished without fear.

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CSO: 4008/2126

S&T ACTIVITIES IN SHANGHAI BUSINESS DESCRIBED

Hong Kong LIAOWANG [OUTLOOK] in Chinese No 23, 9 Jun 86 pp 18-19

[Article by Shen Shiwei [3088 0013 4885] and Wu Oufei [6762 7743 7378]: "Shanghai High Technology Enterprises on the Rise"]

[Text] In the auditorium of the spacious Shanghai Exhibition Center a robot carrying flowers greeted visitors, saying "I am a robot and have a brain just like people!" It then extended itself freely and showed off the movements of bending, extending, holding up, grasping, and holding. It could also move forward, backward, left, and right and sing a tuneful song in a human voice.

This was a wonderful exhibition by a robot at the recent "Exhibition of New Technologies and New Industries" in Shanghai. This exhibition vividly displayed the abundant achievements Shanghai has obtained in the fields of high technology. Of the 670 new technologies displayed shown at the exhibition, the majority were of an international standard of the late 1970's and early 1980's. Some even belong in the international forefront, showing the bright future of Shanghai in developing its knowledge and technology intensive industries.

The Challenge of the New Technology

The revolutionary tide of new technology in the world that has arisen so abruptly has first affected the industrially important Shanghai, on the western edge of the Pacific, which faces a serious challenge. Traditional industries that have unreasonable production structures, are wasteful of energy, and consume many raw materials have been the most favored, while traditional industries themselves have been restrained by the dual constraints of technical obsolescence and space saturation. The former advantages are eroding, some name-brand products are losing their competitive capacity in both domestic and foreign markets, etc.

To meet this challenge, Shanghai has organized more than 1,600 specialists into undertaking large scale surveys, demonstrations, and forecasting to explore new strategies for the development of Shanghai's economy and society. Their unanimous opinion has been: to respond to major trends, to regulate industrial structures, to greatly develop knowledge and technology intensive new industries, and to use the new technologies to arm and transform traditional industries. To this end, Shanghai Municipality has designated the seven high technologies of microelectronics, new materials, biological engineering, optical communications, lasers, marine engineering, and human simulation machinery to be the foci of development and to be allowed to take the lead in forming industries. This will consequently infuse the Shanghai economy with a new vitality.

Making the Most of Advantages

Regarding the development of high technologies, Shanghai is endowed with certain conditions: first of all, there is a powerful and abundant science research development contingent, there are more than 1,000 science research organizations in the city, more than 50 institutes and higher institutions, 550,000 scientists and technicians, and a group of high level academic leaders. In some high technology fields, Shanghai stands at the forefront in terms of the numbers and quality of people. At the same time, there is a rather good research and development base in Shanghai for the high technology fields, some higher technologies having started here domestically. Computers and new materials began to be studied and built here in the late 1950's. For example, integrated circuits and lasers began in the early 1960's, and genetic engineering and fiber optic communications started up in the mid-1970's, all of which began follow-up research soon after appearing internationally. In addition to this, Shanghai is the "center" of ocean, land, and air transportation, with a great deal of data flow. The newest international technical information can get to Shanghai quite quickly, which provides information resources for the development of high technology industries in Shanghai. By developing these advantages, Shanghai has the potential of being the leader in this country for developing high technology and for serving as a "pathfinding vanguard."

To develop high technology industries, Shanghai is currently adjusting industrial and product structures in a gradual and selective way, and in accordance with the requirements of less energy consumption, fewer materials used, fewer quantities shipped, fewer of the "three wastes," and of being highly technology intensive and having high added value to products, is compressing products that become extensive, controlling low-grade products, developing products of high technology, all of which allows Shanghai industries to change from the extensive model to an intensive one, and to change from primary reliance on material resources to primary reliance on technical advances.

Advances That Will Attract Notice

To open up high technology industries, the science research departments and enterprises of Shanghai are currently breaking through the restraints of "creating barriers" and of ownership by departments and have made remarkable advances in the areas of cooperating to handle problems and firming up the basis for science research development and industrialization:

A group of research achievements of advanced world standards have come into being, some of which have already "left" the laboratories. As for example the 4K-bit CMOS static RAM that was developed by the Metallurgy Institute, Shanghai, of the Chinese Academy of Sciences that is undergoing testing. This chip has the advantages of low energy consumption and high resistance to interference, has attained the levels of the 1980's, and may be substituted for similar products from abroad. The major focus problem-solving project "single mode optical fiber technology" of the State Science and Technology Commission during the Sixth 5-Year Plan (1981-1985) is undergoing evaluation in Shanghai, which shows that the Chinese single mode optic fiber applied chemistry research has made great advances and that the research has entered the ranks of the world's advanced. The Shanghai Silica Glass Factory is about to undertake the production of conventional single mode optic fibers, which will provide the material basis for the industrialization of fiber optic communications. The liver cancer monoclonal clone antibody developed by units of the Shanghai Cellular Biology Institute of the Chinese Academy of Sciences is a major weapon against the never before controlled liver cancer. This progressive achievement in biological engineering occupies a leading position throughout the world.

To promote the transformation of high technology achievements into production forces, Shanghai is in the process of paying close attention to the building of a group of high technology intermediary experimental and developmental bases. Those among which that have been established in cooperation with the Chinese Academy of Sciences are the Shanghai Biological Experimental Base, the Chemical Materials Intermediate Experimental Base, the Large Scale Integrated Circuits Science Research and Development Base, and the Vegetable Irradiation Preservation Intermediate Experimental Research and Radiation Technology Base for Dissemination of Applications. The first phase project for the radiation base has been finished for the most part, the overall area of which is 4,000 sq m and which is equipped with radiation fields, loading fields, and control rooms. This base has begun trial operations. Planning is currently underway for the Cao-Jing Rivers microelectronics industrial area that has been called the "Shanghai Silicon Valley." This high technology industrial area will concentrate the computer, LSI, fiber optic communications, and laser industries to gradually form a "window" on Shanghai's high technology industries. Development companies for this new industrial area have already begun operations, and LSI base engineering has broken ground and started work.

Many science research units cooperate with factories to form research--intermediate testing--production "chains," which has speeded up the process of developing high technology industries. After units of the Shanghai microbiology institute completed research on using fixed yeasts to produce beer, they immediately undertook intermediate experimentation with the Shanghai Huaguang Beer Plant. They went on to use those findings in mass production, which allowed the time for the production of beer at this factory to be reduced from the original 21 days to 13 days, greatly improving the quantities of beer produced. In a few months, this biological engineering technology was disseminated to more than 10 beer plants in Shanghai and elsewhere.

Microelectronics, fiber optic communications, lasers, biological engineering, and marine engineering have already taken quick steps toward industrialization. Scientists and technicians from more than 100 research institutes and from higher institutions and enterprises have begun to cooperate, disseminating more than 13,000 microcomputers into the professions of textiles, metallurgy, posts and telecommunications, light industry, transportation and shipping, chemical engineering, machinery, and broadcast television, successfully developing more than 1,000 applications projects, from which they have obtained clear results. At present, Shanghai has applied microcomputers in the establishment of 27 information banks of 8 different types, which has provided an information basis for strengthening overall control of economic activities. Fiber optic communications are at a particular early stage, where production capacity for optic fibers throughout the city has reached from 3,000 to 4,000 km. There is a certain scale of production for terminal equipment of all sorts and optoelectronic components. Fiber optic communications have begun to be applied in the fields of telephony, electric power, broadcast television, public safety, transportation, and data transmission. Laser technology has also begun to penetrate in the applied areas of steel plate cutting, soldering, and hole drilling. At the same time, laser medical instruments and laser diagnostic technology have begun to enter the medical field.

High technology depends upon traditional industry expanding its "area of permeability" to open up the fields for application. As Shanghai develops high technology it is paying attention to "grafting" and "injecting" new technology into traditional industries. In this way, on the one hand traditional industry is allowed to replace its "shell" and to glow with vigor, while at the same time allowing the products of high technology to have fields in which to be applied. From this, both gain. With the cooperation of factories, units at the Shanghai Academy of Textile Sciences have connected computers to the cloth machinery, which provides strict monitoring and management of the production process, leading to a great rise in product quality and production efficiency. Certain new materials have begun to enter traditional industries in Shanghai. In the process of developing special engineering plastics, units at the Shanghai Plastics Institute developed a modified polyformaldehyde chain link to substitute for stainless steel chain links, which when used in the more than 10 factories like the Shanghai Yimin Food Products Factory #1 and the Meilin Can Factory alone saved 10 tons of stainless steel. Currently, the production quantities of new materials such as structural composite materials, special high molecular materials, man-made crystals, and functional ceramics produced in Shanghai are more than one-third of output for the entire country.

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CSO: 4008/2117

XINJIANG TECHNOLOGY IMPORTS FOR 7TH FYP DETAILED

OW021148 Beijing XINHUA in English 1037 GMT 2 Oct 86

[Text] Beijing, 2 Oct (XINHUA)--By 1990, the Xinjiang Uygur Autonomous Region will have spent U.S.$162 million plus 486 million yuan to import 170 projects of foreign advanced technology, the ECONOMIC DAILY reported today.

The regional government decided that the first imported items will be those connected with the region's food, packaging and leather industries, the paper said.

The advanced technology will be introduced especially to the food industry in Kashi, Hetian and Xinyuan in southern Xinjiang to boost their milk and fruit products.

Sophisticated machines will be brought in to improve the region's fur and hide garment and shoe production. Also, techniques and equipment to produce hygienic soft packaging will be imported to help the region keep its surplus fruit fresh.

By the end of last year, the region had already imported 58 technological projects worth U.S.$37.9 million. An assembly line imported from Switzerland to produce hami-melon juice and jam enabled the residents to enjoy the soft drink made from the famous hami-melon for the first time in history.

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CSO: 4010/2002

NATIONAL DEVELOPMENTS

COMPUTER MANUFACTURING INDUSTRY TO BE DEVELOPED

OW101139 Beijing XINHUA in English 1036 GMT 10 Sep 86

[Text] Beijing, 10 Sep (XINHUA)--Over the next five years China will develop an electronics industry based on high technology software and computer manufacturing.

This decision was announced by Xie Gaojue, vice-minister of China's electronics industry, at a meeting here today which was attended by diplomatic envoys and company representatives from foreign countries based in China.

Computer manufacturing plants are now being built in Beijing, Shanghai and Wuxi. This will allow China to mass-produce integrated circuits, microcomputers and other micro-electronic products and to improve their quality, said the vice-minister.

Xie said China has already mastered the latest computer technology and is now doing research into more advanced applications of the technology.

Great efforts will be made to develop communications equipment using satellite, microwave and fiber optics. China also wants to produce more digital switching equipment and computer terminals, Xie said.

So far, there are more than 135,000 computers of different types in the country. The Chinese-made "Great Wall 0520" micro-computer and Chinese character processing software are up to the advanced international standards. China has also succeeded in developing a supercomputer capable of making 100 million calculations per second.

In the future, the vice-minister said, efforts will be made to popularize the use of computers, train skilled personnel and develop better information services.

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CSO: 4010/1003

TIANJIN SETS UP TECHNOLOGY DEVELOPMENT GROUP

OW050536 Beijing XINHUA in English 0011 GMT 5 Sep 86

[Text] Tianjin, 5 Sep (XINHUA)—Tianjin has set up its first new technology development group together with firms in Beijing and Jiangsu Province.

This is one of the latest moves taken by this leading industrial and port city in north China to broaden its economic ties with other parts of the country, officials here said.

The 40 members of the Tianjin New Technology Development Group will work together to design and develop new products, run joint ventures using new technology and spearhead the use of new technology and equipment.

Ling Zhaoyuan, chairman of the group's board of directors, said it "will help raise China's scientific and technical level."

The group has decided to start some 90 cooperation projects. Firms of the United States, Britain, Japan, Singapore, Canada, Federal Germany and France will participate in 26 of these.

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CSO: 4010/2002

WORK OF CHINA S&T ASSOCIATIONS APPLAUDED

Hong Kong LIAOWANG [OUTLOOK] in Chinese No 25, 23 June 86 pp 12-13

[Text] The 3d Congress of the China Science and Technology Association that opened so ceremoniously, where more than 1,800 representatives from all over the country gathered in the capital, could also be called a "conference of science and technology heroes."

The China Science and Technology Association, made up of national learned societies (associations, symposia) and local science associations, is a public organization of Chinese scientific and technical workers, and is the link between the party and the government on the one hand and the scientists and technicians on the other, and is an aide to the development of science and technology.

The aims of the China Science and Technology Association are to promote the prosperity and development of science and technology, to promote the distribution and application of science and technology, to promote the maturity and improvement of science and technology personnel, and to make contributions to improving scientific and cultural levels for all Chinese people.

The national congress of the China Science and Technology Association meets once each 5 years. At the second national congress, held in 1980, Comrade Hu Yaobang made an important speech in which he pointed out that "the S&T Association is an organization for scientists and scientific and technical workers," and "on the road of the advance guard of modernization, the S&T Association holds an important position." He hoped that in the great mission of the S&T Association to open up intellectual resources, they would "play a great historical role."

At present, there are 138 national societies (associations, symposia) in the China S&T Association, with 1.8 million members, as well as 3.5 million Science Popularization Association members distributed throughout towns and townships. For 6 years now, they have done much work in keeping with the needs of trend developments and in promoting the prosperity and popularization of science and technology. Chief among this work has been:

1. Centering on the strategic points of the 12th CPC Congress and the primary topics for research established by the state, they have organized scientific and technical workers to develop in all sorts of ways multi-discipline, comprehensive academic exchanges, have investigated development strategies, and have provided a scientific basis that has allowed the scholastic viewpoint to be changed into decision making thinking. More than 20 associations of Chinese agriculture, forestry, and water conservancy and regional science associations have organized comprehensive academic discussions regarding development strategies for agriculture in the Huanghai-Huaihe area, the northern arid and semi-arid regions, the Nansha islands, and the Shanghai economic zones. They have proposed strategic thinking and technical measures based on the differing natural conditions and levels of economic development regarding development of large scale agriculture in accordance with local conditions and preserving the agricultural ecological environment, and regarding adjustment of rural production structures, all of which have promoted the development of the rural economy.

The China Energy Resources Symposium arranged for more than 500 specialists to draft the "Recommendations for an Outline of China's Energy Resources Policy" after scholastic conferences. This group proposed development strategies for energy resources that lay equal stress on development and energy conservation and that have gained the respect of relevant state departments.

To meet the challenge of the new technology revolution, the China S&T Association has joined with other relevant departments to arrange for 72 associations and provincial and municipal S&T associations in Liaoning and elsewhere to exhibit Chinese research in the year 2000. They have amassed 13 million words of materials for reference by relevant departments in formulating long term plans. This abrupt development of scholastic activities has also accelerated developments in the rising new disciplines, fringe disciplines, and crossover sciences of system sciences, ecological sciences, environmental sciences, and biological engineering.

2. With the support and guidance of science associations and societies at all levels, more than 41,000 town and township science popularization associations and of more than 60,000 special technology symposia have popularized and applied technologies for vast numbers of farmers through the various modes of science popularization publicity, technology contracts, technical services, technical demonstrations, and technical training. They have helped farmers rid themselves of poverty and attain wealth, have developed the commodity economy, and have served as "intermediaries." This is especially true for the various public special technology symposia set up in the countryside throughout China, where those proficient in the technology take charge and motivate the rural households to undertake specialized production and to open up new industries. Some have developed into technical and economic associations, which have stimulated the adjustment of rural production structures, and allowed agricultural production to change toward specialization, toward commodities, and toward modernization, as well as exhibit a strong vitality. For 6 years now, S&T associations at all levels have held together with relevant departments all kinds of farmer technical training classes, which has allowed 80 million people to receive short-term instruction. National societies and provincial and municipal S&T associations

have sponsored more than 76 different science popularizations periodicals, for each issue distributing 10 million copies; 42 publicly distributed science and technology journals, each issue distributing 8.8 copies; science popularization activities such as popularization publications and live demonstrations have also had new development. The science education film "The Wizard's Tricks," produced by the Beijing Science Education Film Company with the aid of the Chinese Institute of Science Popularization and Creativity has been broadly welcomed by the public, 1,400 copies having been distributed.

3. S&T associations at all levels have made full use of the characteristics of the many science disciplines, lateral relations, and unconventional positions to energetically develop scientific and technical consulting services, accelerate the socialization of science and technology, and to generate broad-based social and economic results. With the authority of relevant departments, the Baogang Advisory Commission organized by the Shanghai Municipal S&T Association made more than 60 recommendations, among which the demonstration and decision making consultation regarding starting the second stage engineering of the water channeling plan has moved construction at Baogang smoothly along, and has been praised by relevant sectors of the central authorities and by the Shanghai Municipal S&T Commission. During the period from 1984 through 1985, the Anhui Provincial S&T Commission provided consulting services for 200 small and medium enterprises, completing in all 2,700 consultations of all types, and creating a production value of 630 million yuan.

4. Scientific and technical training activities of all kinds and levels were begun. Over the last 6 years, 200,000 people annually have studied at training classes and lectures on new technologies that have been held primarily for mid-level scientists and technicians by national and provincial level societies. And local S&T associations have restored or newly built 86 science and technology extended training institutions, allowing 400,000 scientists and technicians to receive a more systematic instruction. Science associations at all levels have also begun general technology and new technology training activities of many different kinds. There are for example full scale broadcasts and television lectures on quality control, systems engineering, mechanized drafting, electronic technology, and microcomputer applications, with audiences of more than 20 million people. Activities sponsored by the China S&T Association together with relevant departments, such as "Lectures on the New Technology Revolution," "the mayor's study class," and "Lecturers on Modern Knowledge," have allowed more than 100,000 leading cadre of all levels to learn appropriate scientific and technical and management knowledge. There have also been 2 national youth invention and creativity competitions and science conferences; and 100,000 youth have been able to participate in computer science and technology activities.

5. There has been a wide ranging initiation of international academic exchanges and scientific and technical cooperation, and an opening of channels for scientific and technical exchanges among peoples. More than 10,000 foreign specialists have participated. By meeting with nearly 20,000 foreign and overseas Chinese scholars and holding more than 1,000 academic public lectures, scientists and technicians in this country have been allowed to know of international scientific and technical information in a timely manner. For

some years now, relevant societies have sent forth more than 1,000 scientists and technicians abroad for observation, teaching, and further study. The "Public Lectures on Traveling Abroad" sponsored by the Chinese Medical Society has invited those who have traveled abroad to speak on new foreign technology and information, by which when one person goes abroad, many benefit. The rightful positions of the China S&T Association on the council of the International Federation of Scientists and of the World Federation of Engineering Organizations have been restored, relevant societies have become part of 88 international science and technology scholastic organizations, some 200 scientists among them taking on leadership positions, and contacts have been established with more than 100 science and technology organizations in 40 countries and regions. The "Exhibition of Chinese Ancient and Traditional Technologies" organized by the China S&T Association has appeared in both Canada and the United States, which has expanded its international influence.

6. They have played a central role in protecting the legal rights of scientists and technicians and in helping the party to implement policies for intellectuals. In recent years, S&T associations at all levels have surveyed and studied the conditions regarding implementation of policies toward scientists and technicians and regarding fulfillment of their functions and have reflected the opinions and needs of scientists and technicians to the party and the government. Also, they have done beneficial work in improving working conditions and living conditions for scientists and technicians and have promoted the rational employment of personnel. The science and technology extracts compiled by the S&T associations of Shanxi, Fujian, and Hubei provinces have furnished important reference materials for the party and the government regarding the promotion of personnel. The "Standards of Science Morality for Scientists and Technicians in the Capital" proposed by Mao Yisheng [5403 0110 0581] and 103 scientists has been answered by the majority of members. In collaboration with the State Nationalities Commission and the Ministry of Labor and Personnel, the China S&T Association awarded certificates of honor to 32 scientists and technicians who have worked in minority nationality and frontier areas for more than 30 years, and commemorated 1,800 advanced scientists and technicians among them, encouraging their spirit to build the frontiers.

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NATIONAL DEVELOPMENTS

MORE ATTENTION URGED FOR HEAT TREATMENT TECHNOLOGY

Beijing ZHONGGUO JIXIE BAO in Chinese 5 Aug 86 p 2

[Report by Liu Dai [0491 6610], secretary-general, Conference on Heat Treatment, Chinese Association of Mechanical Engineering: "Problems in the Development of Heat Treatment Manufacturing Technology"]

[Text] To allow the machinery industry in this country to attain the current production levels of advanced industrial countries by the end of this century, we must change the situation regarding backward techniques in the machinery industry as quickly as possible. Here, I would like to discuss some of the problems in the development of heat treatment production technology.

Adopt vigorous measures to develop advanced heat treatment equipment and limit the production of backward equipment.

At present, the heat treatment production technology in this country is only up to the level abroad during the 1950's or 1960's, a situation evidenced by obsolete equipment, the inability to control the production process, deficient quality of components, and a short life.

Among the 100,000 pieces of equipment in the heat treatment trade in this country, there are 10 percent too few protective atmospheric furnaces and vacuum heat treatment furnaces, the majority of which are box furnaces and well furnaces for heating in an oxydizing atmosphere, as well as old style highly energy consuming salt bath furnaces, induction heating equipment, and well-type carburizing furnaces. If by the end of this century we are to attain current foreign levels of heat treatment manufacture, we must at least eliminate half of our old obsolete equipment. Always in consideration of the equipment utilization rate and production capacity, beginning now we must use 1,000 new pieces of equipment annually to replace 300 pieces of obsolete equipment. Obviously, we cannot use imported equipment to renew and replace. Although at present there are some electric furnace plants that can produce a small quantity of high quality equipment, but whether from the aspects of quality, variety of product, or quantity, we are far from being able to satisfy the need. For various reasons, there is still great demand for the old-style equipment. Electric furnace manufacturing plants are willing to manufacture this high profit equipment that has a low requirement for technology. Therefore, we are currently maintaining annual output of 2,000 old style pieces of equipment, which puts an ever increasing burden upon the renewal and replacement of heat treatment equipment. This situation should not continue.

The reasons leading to this situation are numerous. First of all, the utilization rate for heat treatment equipment in this country is low, to which we add the simplicity of the equipment and ease in maintenance, the results of which are that we seldom discard it or replace it. Second, we have not yet formed the ability to manufacture advanced equipment. Aside from reasons of technology, low profit is also an important consideration, to which is added the fact that the technology is not mature and the quality of the furnaces is not high, which increase the burden of maintenance for the manufacturing plant. Third, technology levels and the standards of technique are low, so motivation is lacking for the replacement of heat treatment equipment.

Based on these conditions, relevant leading departments must adopt vigorous measures, and quickly turn this situation around. First, during the period of the Seventh 5-Year Plan, we should develop the ability to produce advanced heat treating equipment, and fully use and import advanced foreign technology or undertake cooperative production. We should also use the means of tax revenue to encourage electric furnace plants to produce advanced equipment and limit production of obsolete equipment. At the same time, there should be surveys of the product types and quantities of advanced equipment needed by various machinery commodity businesses, and key enterprises should arrange for equipment replacement. We should arrange jointly with relevant industrial departments for the manufacture of different kinds of materials for the protection of atmospheric gas resources and techniques to ensure the normal operation of advanced equipment. These are all basic conditions for the acceleration of equipment replacement and renewal.

Strengthen Theoretical Research Into Heat Treatment Techniques

Enhancement of heat treatment theoretical research is another important problem in improving the level of heat treatment production technology. Technique is technology, and in many foreign languages 'technique' and 'technology' are the same word. The development of techniques has given a great push to production forces, as for example with the appearance of vacuum heat treatment, by which not only can commodity performance be doubled in performance, but in surface non-oxidizing decarbonization, distortion is small, which greatly reduces the grinding process and lowers costs. Consequently, it may be said that there is still a tendency to neglect technique, which seriously affects the improvement of machinery product quality. If we were to say that state allocations to research in techniques during the "7th Five Year Plan" are pitifully low, that would not do justice to the mission of the entire machinery industry. It would appear that science research expenses can only be used in new, trendy projects, while urgently needed research in traditional basic techniques is still not being seen. That being so, it is just the level of these techniques that is the embodiment of the machinery manufacturing capability in this country. In technique research, we should strengthen intermediary experimental links and use the results from the laboratories in production as quickly as possible. But we should also guard against yet another tendency, that being the sole development of topics dependent upon commodities, for this is simply to concern ourselves only with the economic results directly in front of us. It is quite possible to shatter the research into technique theory that needed strengthening in the first place, thereby increasing the gap between foreign levels of technique and ours. We should not treat all key technique institutes the same way, cutting off all state allocated operating expenses uniformly and forcing institutes to abandon theoretical research into technique. Quite the contrary, the state should enhance and foster them, should renew the equipment of these institutes, use them to import and absorb advanced foreign technology, and join with higher institutions to assume the responsibility for research and development of heat treatment techniques and equipment. We must not imagine that we will only copy after the lead of others, but rather should be taking the lead in certain fields ourselves.

Set Up Some High Quality Heat Treatment Points for a Narrow Range of Techniques

Enhancing specialized production is an effective way of arranging for modernized heat treatment manufacturing. In organizing heat treatment processing plants, we should not only pay attention to the improvement of equipment utilization rates, but should also have advanced equipment and use advanced techniques to better promote technology advances throughout the profession. Our existing heat treatment plants could for the most part manage to be "all-round" plants for various techniques, and although equipment utilization rates would be high, standards of equipment and technique would not be high. Foreign heat treatment specialty plants are not often large scale and they can only do certain kinds of techniques, but their standards for equipment and techniques are higher. Currently, this kind of "all purpose" heat treatment plant in this country is possibly necessary to serve small and medium plants in this regard, but we should also establish some high quality heat treatment plant sites that are limited in the scope of their techniques, so that they might find a place in the heat treatment of key components of medium to large scale machinery plants, and so that they can promote the improvement of levels of technology throughout the profession.

The machinery industry in this country shoulders the enormous burden of providing excellent equipment for all industrial sectors. Heat treatment production technology that is intimately related to machinery product quality suffers greatly in comparison with advanced foreign standards. If we are not sufficiently aware of this, we cannot make immediate use of vigorous measures, which is quite dangerous and is certain to eventually affect the modernization of the machinery industry.

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NATIONAL DEVELOPMENTS

POLICY OF NOT TESTING IN MIDDLE SCHOOL TRIED OUT

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 22 Aug 86 p 4

[Report by Xiao Guangen [5618 7070 2704]: "Director of Shanghai College of Communications Calls For Change in Admission System"]

[Text] Recently, the director of the Shanghai Jiaotong College, Weng Shilie [5040 0670 3525], proposed that to change the admissions system the schools must be given even greater autonomy.

Weng Shilie said that abuses in the admission system that relies solely on test results and records in choosing students are becoming more and more obvious. This is not advantageous to letting talent show itself, for there is no way to fully investigate the natural gifts, intellect, quality, and potential for development of students, and in fact it is difficult to avoid stifling talent. The unified examination constitutes a kind of baton that directs students to one-sidedly seek entrance into a higher school, even to the extent that many middle schools conclude their curricula a term ahead of time and spend the time studying for the upcoming exam. This makes a minority of outstanding students waste their time after having already completed their studies ahead of time. In the past, we often criticized middle schools for one-sidedly seeking entrance into higher schools, saying that it was not fair. As we understand it, many middle school leaders have long felt that to move to keep up with the high school examinations would be a mistake for the outstanding students, and that they urgently hope there will be a change in the admission system for the higher level schools. This would create a situation conducive to the early maturing of outstanding students.

Weng Shilie told reporters that regarding changes in the admission system, for some years now Jiaotong College has been earnestly exploring the situation. In 1980 they requested approval from relevant departments for Jiaotong College to admit students on testing from high schools after not testing when at affiliated middle schools. In 1984 they again requested admitting through testing 77 students from affiliated middle schools who had not earlier tested. But it was only in 1985 that they accepted 220 students from Shanghai and other places who had not tested, even entering school one-half year early so that they could have a good foundation for study. The results have been good. After summer vacation this year, 70 of them will be able to enter at the third year level, one year ahead of students in their class. Some of these exploratory changes at Jiaotong College were first cleared with higher authorities and relevant departments, while some were approved by higher authorities only after initial successes. And of course some were undertaken first and reported later, where reports to the relevant departments were inadequate. However, right from the beginning, leaders and teachers at the middle school welcomed this experiment. This year, the number of outstanding students entered for examinations into Jiaotong College throughout the country is unprecedented, greatly exceeding the limit for acceptance without examination as set by higher authorities, so some very qualified middle school students will not be able to be selected.

Weng Shilie said that the authority with which to change the school admission system also includes the possibility that for truly outstanding students, when the middle school recommends or when the university is admitting, relevant restrictions can be overcome. It is, however, still difficult to select people without anything to recommend them.

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SHANGHAI SHIPBUILDING EXPANSION NOTED

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 15 Aug 86 p 2

[Text] The Shanghai shipbuilding industry has reduced the gap between them and international standards, and can now build ships that comply with any international standard and that navigate in any navigational area. Their manufacturing capabilities and techniques already approach international advanced standards.

According to a report in WENHUI BAO, the variety of ships built by the Shanghai shipbuilding industry has developed from cargo ships, bulk cargo ships, oil tankers, and multi-purpose ships to exclusively containerized, multi-purpose, rolled container, three-way, and special types of ships that are structurally complex and highly technical. Ship tonnage has developed from the 20,000 ton class to the 40,000 and 60,000 ton classes. Shanghai has also cooperated abroad to design a 29,900 ton net oil tanker, a 42,000 ton bulk cargo ship, and a 64,000 ton Panama-type bulk cargo ship. Among products and equipment that are different kinds of ships, main and auxiliary engines, and shipboard instrumentation and power, 57 products have received state gold and silver medals for quality, as well as ministry and municipal awards for outstanding quality. Seventeen items have received national level awards for science and technology advancements, and 8 items have been awarded national level awards for national defense use science and technology advancements.

In recent years, the Shanghai shipbuilding industry has imported well-known manufacturing technologies from Denmark, Sweden, and Japan, which after absorption, assimilation, and innovation, have continued to improve the international extent of imported products and equipment. In addition to particular products, the rate of national production of component parts and parts of systems has reached from 60 to 70 percent. At the same time, some shipbuilding plants have learned from foreign management experiences, have combined the characteristics of the Shanghai shipbuilding industry, and have applied CAD, CAM, and computer-aided management to improve the levels of technical management and operations management. All major shipbuilding factories have expanded their berths and have added area to loading and welding platforms and length to their docks. The have enhanced their capacity for crane transport and have replaced steel processing and welding equipment, which allows them to manufacture various large tonnage ships.

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NATIONAL DEVELOPMENTS

ROLE OF SOFT SCIENCE IN MODERN CHINA DISCUSSED

'Spark' Plans Included

Beijing LIAOWANG [OUTLOOK] OVERSEAS EDITION in Chinese No 32 1 Aug 86 pp8-9

[Article by Chen Siyi [7115 0934 4135] and Zhang Zhichu [1728 2535 2806]: "Leaders and Specialists Discuss the Soft Sciences and the Modernization of Decision Making"]

[Text] The first Chinese "National Soft Sciences Working Conference" obtained predicted results and generated a rather great impact. One reason for this was that those participating in the conference were not only soft science specialists, but also the leaders of the decision making bodies to which they correspond, and some held qualifications in both areas. During the 5-day meeting, people took part in multifaceted, ardent, and candid and sincere conversations, which consequently produced a deeply relevant topic: that the democratic and scientific nature of decision making is an important item in the restructuring of the political system.

On the afternoon of 31 July, the editorial department of this publication invited some of the participants to discuss how to develop Chinese soft science research and the democratic and scientific nature of decision making. We have arranged the results of that discussion as follows:

New Topics Facing Soft Science Research

Wu Mingyu [0702 2494 3842], deputy director of the State Science and Technology Commission: the democratic and scientific nature of decision making has become an important topic in the restructuring of the political system, and soft science research has an even greater sense of timeliness, of mission, and of responsibility. There are at least the following major topics before us at present, topics that require us to expend a great deal of effort in study: there are many articles to be written regarding the study of the future for China in the year 2000. Deng Xiaoping has proposed that by the end of the century, the lives of the Chinese people will be comfortably well off, so what kinds of changes will there be by that time in what people eat, where they live, what they wear, and what they do? What will Chinese industrial structures be like? What will energy resource structures be like? What kinds of changes are likely to take place along the coast, inland, in the major cities, and among industrial groups? These overall problems require us to make decisive plans.

There Is Also An Evolution of Concept

Hu Ping [5170 1627], director of the Science and Technology Promotion and Development Center of the State Science and Technology Commission: We should change the traditional method by which we have been accustomed to rely on the positions and authority of leaders themselves to make decisions, and should go further to establish an entire set of decision making programs and decision making structures for science. This is because the empirical decision making of the past had been developed from a small production basis. In this aspect we are saddled with immense burdens. One is the burden of the traditional concept of 3,000 years of small production; another is the burden of a lack of democracy over the past 30 years; and another is the burden of an anarchism generated by the ten years of "cultural revolution." Both the rather common situation over those 30 years where what one person said was what counted, that concept of relying on experience and authority in decision making, and the situation over the 10 years of the "cultural revolution" in which what anyone said did not count, that anarchistic thinking whereby people did what they wanted, are after all the thinking of small producers.

Science decision making was established on the basis of large production, and has been established on the basis of modern science and technology. If there is no fundamental evolution of concept, then the democratic and scientific nature of decision making cannot be achieved. For example, some of those in authority in departments and localities are used to proceeding from the narrow confines of the advantages for that particular department and that particular region. They pay no attention to the bigger picture, which is thus a small producer's concept. And as another example, soft science research is an exploration of what is not yet known. It can only respect the facts and revere the truth, but leaders of some departments and localities are still accustomed to the empirical decision making of small producers. They frequently require that soft science research bend to their own intentions or comply with their own ideas. Done like this, there is no way to have scientific decision making.

There Must Be Guarantees of Democracy

Wu Xiang [0702 6272], deputy director of the State Council Rural Development and Research Center: Beginning before the cultural revolution, the non-democratic spirit that developed maliciously during the cultural revolution has seriously obstructed the democratic and scientific nature of decision making. What one person says goes, everything is dealt with in the same way, everything is done without thinking, all in a rush-- you can see it everywhere and it is hard to counter in such numbers.

The democratic and scientific natures of decision making are inseparable. The "May 4th" movement mentioned "Mr. De" (democracy) together with "Mr. Sai" (science). Today we still need these two gentlemen. If decision making is to be scientific, it must have democratic guarantees to allow scientists the environment in which to independently carry out research, to not be aware of the feelings of the leaders, and to not be swayed by the intervention of authority. This then requires that leaders at all levels be prepared to disregard the feelings of leaders above them, and rather to determine the nature of a problem according to the actual situation.

Soft Science Research Leads to Correct Decision Making

Pei Yingwu [5952 5391 2976], State Planning Commission commission member: Beginning in 1983, the State Science and Technology, Planning, and Economics Commissions organized study of some 10 major technology policies, and after more than 2 years, the several thousand well-known specialists, scholars, and leading cadre and practical workers from all departments who took part in this finally came up with the essentials of technology policies in 12 major areas. This was the most systematic and largest scale study of technology policy since the founding of the PRC. The State Planning Commission closely integrated the essential substance of these technology policies into planning for the Seventh 5-Year Plan (1981-1985) to form industrial policies and technology transformation plans for the Seventh 5-Year Plan. Regarding directions of technology development, they selected technologies, limited technologies, and phased out technologies, all with clear provisions based on scientific theory. This has allowed planning for technology transformation during the Seventh 5-Year Plan to be greatly advanced along the lines of the integration of economics with science and technology. Studies of Shanghai economic development strategies are a successful example of soft science research providing a scientific demonstration for accurate decision making. During the months of September and October 1984, and following the directive of Premier Zhao Ziyang, the State Council Survey and Research Group, together with the Shanghai Municipal Science and Technology Commission and the municipal government, organized several hundred specialists and scholars together with certain leaders and practical workers to do a large scale, systematic survey and study. They did repeated scientific demonstrations and proposed a report outline of Shanghai economic development strategies, which received the approval of leaders in the Central Committee and State Council.

In the process of the survey and research, there were two different programs. One required that Shanghai develop as an industrial base area to a greater degree, where its primary goal would be a quadrupling by the year 2000 of the Shanghai Municipality agricultural and industrial gross output value for 1980. In this way, during the period of the Seventh 5-Year Plan there would be a 72 billion yuan investment, energy resources, transportation, and shipping would be even more strained and the backward condition of the basic equipment of the city would become even more serious, and it would be hard to improve the environmental deterioration. But also, the advantages of Shanghai--its being a commercial center, science and technology center, important financial center, information center, seaport city, link in the open-door policy, and as a full and varied industrial base--would still not be fully developed; this made what should have been an aspect worth evaluating in the drive toward modernization be demoted to the position of an ordinary city. After exhausting scientific demonstrations, the following direction for development was finally decided upon: to build Shanghai into an open, multi-purpose modern socialist city having reasonable industrial structures, advanced science and technology, and a high degree of civilization.

Viewed from the work described above, an accurate policy must be certain to be the result of a great amount of scientific study and demonstration. Without soft science research, it would have been difficult to have made the accurate decisions in time.

As the Restructuring Needs the Hard Sciences, Even More Does It Need the Soft Sciences

Yu Jingyuan [0060 2529 0337], Assistant Institute Director, Institute No 710, Ministry of Aeronautics: Over the historical period of the full restructuring, China not only needs the hard sciences, but also needs the soft sciences, and to a certain degree needs the soft sciences even more. For example, the primary functions of the "national financial system control model" established by this institute is to ascertain appropriate rates of accumulation; calculate the amounts of currency circulating in the marketplace; undertake economic forecasting, and financial decision making simulations. After forecasting tests through the 2 years of 1983 and 1984, errors for this model did not exceed 5 percent, which meets and exceeds the accuracy of similar international models, and the model was proven to be an applications model that nears reality.

During actual work, I felt that if we were to hasten the modernization of decision making, we would have to implement true democracy, for without it decision making could not be scientific, and might even be greatly in error; if not scientific, decision making cannot represent the basic advantages of the people, nor could we speak of democracy. The two are mutually complementary, and neither can be absent.

Develop Cautionary Advising

Zhang Pan [1728 4323], deputy general secretary of the State Council Economic, Technological, and Social Development Center: Advising primarily serves decision making, and as soft science research, consulting that is predicting and cautionary is very valuable. For example, we recently did some surveys of population growth over the last year or two, and repeatedly warned people that population growth must be strictly controlled or our efforts over the last few years would be in vain, and the goal of families being well off by the end of the century would be difficult to attain. This problem has attracted the attention of the state. Naturally, cautionary advice of this sort can be risky at times, but if risk decision making is to be successful, then we must rely fully on the scientific demonstrations of advising.

There Should Also Be "Spark Plans" for Soft Science

Yang Jike [2799 4764 3784], deputy governor of Anhui Province: I would recommend that the State Science and Technology Commission formulate a "spark plan" for soft science research. During the current development of the Chinese economy and of society, scientific decisions need to be made about many problems, as for example questions of foodstuffs, population questions, environmental questions, etc. To this end we must undertake scientific studies before decision making. These studies should of course be done by relevant government departments, and the science and technology commissions cannot help but organize their efforts to work in parallel with the studies of relevant government departments. In this way there would be at least two plans provided to leaders for their selection, where either the best could be chosen or the best could be combined from each and the Central Committee would formulate the final principles. The People's Congress would formulate laws and regulations, and the government would draw up plans and rules, which would then implement the decisions made.

Establish Two Advising Systems, Internal and External

Liu Ji [0491 0679], vice chairman of the Shanghai Science and Technology Coordinating Commission: With breakthroughs in the democratic and scientific nature of decision making, it is possible to establish a political system that fully exploits the superiorities of socialism. As for example in the past, when we had the streamlining of the military and the government, the streamlining of the government and delegation of authority, etc., where to undertake these kinds of reforms in the area of political systems is undoubtedly in the right direction. However, because we lacked strict studies from the soft sciences, the streamlining did not proceed from the functions of government departments, and although we established a highly effective, self controlling system, its goals have been quantitative. As a result, what are invariably cut first are brain trust structures and feedback structures. So the main problems for China's administrative structures have been overstaffing of system personnel, where the quality has not been high, and where what needs to be strengthened are just those brain trust structures and feedback structures.

When making decisions, leaders listen to the opinions of specialists and should distinguish the advice of internal specialists from that of external specialists. The advice of internal specialists is very significant, but because they are directly subordinate to department leaders, it is unavoidable that they would be affected by information and opinions from leaders. There can even be administrative interference and the likelihood of losing an impartial, objective perspective. Therefore, we must also seek the advice of external experts. The advice of external experts is not only more likely to be impartial, but can also better reflect the opinions and needs of various aspects of society, and is blessed with a comprehensive consideration of the situation. In general, we would hope that when leaders are making decisions, they would at least have two kinds of reports: the suggestions of internal specialists and the evaluations of external experts. The virtues of both would clarify the situation, and errors in decision making might be avoided.

There Should Be Great Proficiency About Soft Science Studies

Feng Zhijun [7458 0037 3182], institute director, Shanghai Institute of the Study of Science: There must be great proficiency in soft science studies. This great proficiency is first manifest in the scientific nature of research methods. The considerable progress made by modern natural sciences, and especially the harmonious convergence of the natural sciences with the social sciences, has laid the foundation for great proficiency in the soft sciences. This is primarily exhibited in four areas:

First, the objects of study in the soft sciences are usually non-linear, fuzzy, dispersed, random, and spontaneous, and the armory of the modern natural sciences has not provided powerful weapons to resolve these problems, while new advances in the modern natural sciences have provided possibilities.

Second, constant advances in computer technology, and especially the continued maturing of emulation, expert advising systems, and systems dynamic modeling have provided extremely good technical means for soft science studies.

Third, the research achievements of control theory, information theory, systems theory, dissipation structures theory, coordination theory, and even the research achievements of disorder theories, have provided effective tools for studying sequentially organized problems and for establishing the logical and mathematic models for decision making;

Fourth, developments in psychology, social psychology, and other fields of the social sciences have provided valuable analytical means for studying the psychological structures and psychological process of decision making.

Having excellent scientific tools is certainly not the equivalent of being able to solve practical problems, for great proficiency is still needed to solve the real problems in this country. The research achievements of the soft sciences should be as complete, quantitative, time efficient, tolerant, and hierarchical as possible, and they should make use of the three techniques of logical models, mathematic models, and emulation technology to allow the level of soft science studies to rise even higher.

Soft Sciences Personnel Should Be Respected and Fostered

Zhang Bihui [1728 4310 2547], assistant academy director, Huazhong Engineering Academy: Soft science is the product of the cross fertilization of many science disciplines. It is comprehensive research that transcends departments and disciplines, and the object of which is also largely a macroscopic system concerned with the national economy, society, and science and technology. For this reason, soft scientists are hard to come by and leaders at all levels should pay them special respect. But the situation until now has been that scientists and technicians in the hard sciences are favored over those of the soft sciences, and soft science personnel have invariably been labeled as "generalists." Actually, soft science uses the theories and methods of many sciences, it uses advanced calculations and techniques, and through logical, mathematic, and emulation models combines the qualitative with the quantitative to propose optimal programs for the resolution of various problems, which makes it very useful. As society revolves so quickly, a new way of thinking or the decisions of a science can revive a particular industry and can make a unit rise to prosperity. Naturally, this must be done through the exploratory and creative arduous efforts of soft science personnel. People of this type will generally have a background in the natural sciences, a wide ranging knowledge base, and a strong analytical, integrating, and resilient capacity. This kind of person is conditioned through a long period of practice, and cannot be summoned up at will. Therefore, besides respecting these people, we should also include the fostering of soft science personnel in the planning of the higher institutions. One part of this planning is the cultivation of dual role students.

Soft Science Situation

Beijing LIAOWANG [OUTLOOK] OVERSEAS EDITION in Chinese No 32, 11 Aug 86 pp10-11

[Text] Soft science is a product of the mutual cross fertilization and permeation of the natural sciences, engineering technology, and the social sciences, and primarily studies the coordinated development of society, the economy, and science and technology. It simplifies policy problems in modern society, serving the scientific nature of decision making and the modernization of management.

In recent years, soft science studies in this country have developed quickly. In the survey organized this year by the Office of Policy of the State Science and Technology Commission of domestic soft science research, the situation was found to be as follows:

Soft Science in China Is Beginning to Take Shape

According to a preliminary survey, there are 420 organizations throughout the country engaged in soft science research, among which 25.6 percent belong to various national departments, 34.3 percent are affiliated with the provinces, municipalities, and autonomous regions, and 40.1 percent with the higher institutions.

There are approximately 150,000 people engaged in soft science research, among whom 10.3 percent are high level research personnel and 35.2 percent are middle level research personnel.

Among the 1,735 soft science projects which have been completed, 29 percent were completed by research organizations of national departments, 35.2 percent were done in provinces, municipalities, and autonomous regions, and 35.8 percent were done in the system of higher institutions.

Soft Science Research Is Primarily Characterized in the Following Way

A group of professional soft science research organizations have been established to serve higher echelon decision making. There are, for example, the State Council Economic, Technological, and Social Development Research Center, the Rural Development Research Center, the System Restructuring

Research Center, the State Planning Commission Forecasting Center, the State Science and Technology Commission Science and Technology Promotion and Development Research Center, and the State Economics Commission Information Center.

Many provincial and municipal laboratories that are administrative units for organizations have been expanded to be specialized soft science research organizations, as for example the Provincial and Municipal Technology and Economic Development Research Center, the Institute of Provincial and Municipal Development Strategies and Policies, and the Economic Research Center. These formats specialize in policy research, which allows for the situation in which their organizations are apart from administrative systems, guaranteeing the position of soft science in decision making links.

There has been a true integration of the cross fertilization between the natural sciences and the social sciences, and a group of natural science research organizations have been opened to the soft sciences, a group of natural scientists and engineering specialists have shifted to soft science or do soft science research as well.

There is more and more vigor in research into the study of science, for which some research organizations have been established; as for example the Institutes for the Study of Science in Shanghai, Tianjin, and Beijing.

There is a clear trend in the higher institutions for the emergence of cross fertilization between science and engineering courses and the social sciences.

The advising industry is just now flourishing in this country, especially technical consulting and demonstrations for large projects, which has also generated great social and economic results.

In view of foreign soft science research in the mid and later 1970's, Chinese soft science during the Sixth 5-Year Plan began to be applied in several areas, the obvious characteristic of which has been the necessarily close connection between soft science research and economic construction, and from which research results have been seen.

Soft science research serves overall decision making by the state, as for example the compilation of the "Table of National Investment and Output Values" that included 24 economic departments and the building of the national macroscopic economic model.

Large scale technology policy research and demonstrations have begun, and major soft science projects like "China in the Year 2000" have been completed.

In the forecasting of science and technology development, the requirements for closely integrating the needs of actual decision making and management have begun a group of large scale research projects. As for example study of the state energy resources model; forecasting the development of the unification of machinery with electronics; forecasting research into the future for Chinese microelectronics technology development; forecasting of Chinese information systems development; studies of science and technology target systems; surveys and forecasting of Chinese industrial technology levels and models; comprehensive analysis of large city transportation and shipping; studies of urban ecological systems; research into China's electric power planning; agricultural systems engineering, and studies into the forecasting of greater agricultural development.

Integration of local characteristics to develop soft science research, as for example the research into development strategies for the nation's capital; studies of Shanghai's economic development strategies, and studies of energy resource divisions in Shanxi Province.

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NATIONAL DEVELOPMENTS

SYSTEMS ENGINEERING RESULTS IN DALIAN AREA DESCRIBED

Beijing RENMIN RIBAO in Chinese 8 Aug 86 p 3

[Text] A soft science research contingent at the Systems Engineering Laboratory at the Dalian Engineering Academy, led by Professor Wang Zhongtuo [3769 5883 2094] and made up of the young, middle-aged, and senior, has completed more than 20 research and development projects over the last 9 years, about half of which have been adopted for use or have been applied in actual production.

In the aspect of research into network planning technology and dissemination of applications, the computer software system that they have developed, having a decision key routing method, composite network method, and network planning management, has been applied domestically at several enterprises with excellent results. With figures from only some 10 factories, increased output value has been 60 million yuan, with profits and tax revenue of more than 13 million yuan. The network planning technology has been used in the manufacturing process for the radio-cassette 2L141 pattern die made by the Shanghai Radio Factory No 2, and the period for the manufacture of the entire set of molds was reduced from one-half year to 3 months, from which was realized an increase in output value of 1.154 million yuan, with a profit of 214,000 yuan. This achievement won a first prize from the Shanghai Municipal Economics Commission.

In the area of energy resource systems engineering, they researched and developed for the department of electric power development planning models and software for development of a thermoelectric power source. After analysis and application of the second loop engineering from Liujiaxia to Guangzhong, it was shown that in comparison with traditional manual planning the lesser amount of water used at the hydroelectric plant converted to 400 million kwh of electrical energy; in an application for another project, annual expenses of 9.248 million yuan were saved. At the evaluation conference by relevant departments, this was considered to be the first model and software to reach the level of actual use in this country.

In the area of agricultural systems engineering, the research that they did on agricultural and industrial structures on behalf of Wafangdian, affiliated with the city of Dalian, and the analysis of the optimal reasonable distribution of fruit trees and food crops in this apple base area, produced results that have been adopted by the Wafangdian municipal party commission and the city government. Based on the planning of Liaoning Province regarding establishment of agricultural modern model counties, they are also currently doing research on establishment of a county level comprehensive economic information and decision making system on the basis of a computerized natural resources data bank and planning system that is centered on Kalaqinzuoyi Mongol Nationality Autonomous County.

Regarding analysis of water resource systems, they have done certain plans for Angang concerning rational use of water. They did quantitative analyses of the relations between amounts of water used in Angang and underground water locations, from which they could provide data for reference in decisionmaking.

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NATIONAL DEVELOPMENTS

YOUNG RESEARCHERS AWARDED FOR S&T ACHIEVEMENTS

OW301630 Beijing XINHUA in English 1531 GMT 30 Aug 86

[Text] Beijing, 30 Aug (XINHUA)--Eleven young scientific researchers whose work has been judged as meeting internationally advanced standards will be awarded prizes, it was announced here today.

Under the auspices of the Beijing Science and Technology Association, the prizes are the first to be bestowed on people under 35 years old who have made scientific achievements. The prizes will be awarded every two years, according to an association official.

Selected from 122 outstanding young scientific researchers, the winners will receive 1,000 yuan (about U.S.$270) each, equal to an ordinary worker's annual wage.

The youngest, 23-year-old Huang Yidong, gained a master's degree at the Beifang Jiaotong University in Beijing two years ago. Last June three of his papers received special attention from the two committees of the International Photographic Surveying and Remote-Sensing Society, and were included in a collection of conference papers and the international photographic surveying files.

Another prize-winner, Feng Changgen, won his PHD from a British university and has issued an average of almost eight papers a year since he returned home in 1982. He has reported his scientific findings to seven influential international academic conferences.

An official of the Beijing Science and Technology Association told XINHUA that these young researchers have selected scientific subjects which combine China's actual needs with international scientific development, and positively put the theory into practice.

He said that a prize-giving ceremony will be held 14 September in Beijing.

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CSO: 4010/2002

NATURAL SCIENCE FOUNDATION TO AWARD RESEARCH GRANTS

OW181547 Beijing XINHUA in English 1150 GMT 18 Oct 86

[Text] Beijing, 18 Oct (XINHUA)—China's State Natural Science Foundation Committee which supports basic and applied research will publish results from a number of research projects, according to today's overseas edition of the PEOPLE'S DAILY.

Since it was established this February, the foundation committee, which is an academic body made of scientists and experts funded mainly by the state, has received about 12,000 applications for research projects.

To fund all the projects the committee could spend about one billion yuan (U.S.$270 million), the paper said. The committee has organized a panel of scientists to assess the applications before granting financial support.

The aim of the foundation is to promote scientific research and encourage competition. All scientific workers in China are eligible to apply for grants from the foundation. The foundation committee will also set up a special fund to discover and train more young scientists.

In addition, it will conduct academic exchanges with counterparts in other countries through joint research projects.

The committee's major tasks include developing guidelines for basic and applied research, organizing scientific grant review panels, providing advice on basic and applied research policy, and expanding cooperation with foundations and academic organizations in other countries, according to a State Council circular.

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NATIONAL DEVELOPMENTS

BRIEFS

INCREASED EXPORT OF ELECTRONIC PRODUCTS--Beijing, 7 Sep (XINHUA)--China almost doubled its export of electronic products to the European, American and Southeast Asian countries in the first half of this year, according to the CHINA ADVERTISER today. Deals concluded in the first six months were worth more than U.S.$223.3 million, up 90.97 percent from the same period last year. In recent years, marked improvement has been shown in the quality of television sets, radio cassette recorders, radio sets, electronic organs and satellite ground stations sold to these areas. [Text] [Beijing XINHUA in English 0610 GMT 7 Sep 86 OW] /9738

HI-TECH PRECISION INSTRUMENT--Beijing, 14 Sep (XINHUA)--China has succeeded in developing a kind of hi-tech precision instrument--program controlled frequency scanning signal generator--which will be put into mass production soon. The overseas edition of the PEOPLE'S DAILY quoted hi-tech experts as saying that the success has filled a gap in China's microwave automatic measuring and testing technology. The technical performance of the instrument has reached the 1980's level of similar products in the world and the price is half as much, the report says. China used to depend on imports for the supply of such instruments and now orders have kept coming in from all parts of the country for the newly developed product. It is estimated that it will save nearly U.S.$100 million of foreign exchange. Developed by the Tai'an Qinghua Instruments and Meters Plant in Gansu Province, the new product is widely applied in testing, developing and maintaining satellite ground stations, microwave relay stations, radars and laser equipment. [Text] [Beijing XINHUA in English 0705 GMT 14 Sep 86 OW] /9738

SHANGHAI RADIATION TECHNIQUES CENTER--Shanghai, 19 Sep (XINHUA)--China's first center for the popularization of the application of radiation techniques to production was approved by the authoritative Chinese Academy of Sciences today after four-month trial operation, in China's biggest industrial city of Shanghai. The center, with a loading capacity of 500,000 curies covers an area of 4,000 sq meters. It contains facilities for radiation, a loading and unloading yard, a control room and a laboratory, according to an official of the center. The radiation center, easy to install and economical, is particularly suitable for developing countries. It will provide complete sets of equipment and train personnel for other countries after it starts operation soon. The radiation techniques involved include those to keep foodstuffs fresh and disinfect medical apparatus. Tests show that radiation reduces the rate of decay of apples by 20 percent; it only costs the equivalent of two U.S. cents to radiate one kg of apples. Chinese scientists began to study the peaceful uses of nuclear energy in the 1950s. Radiation techniques have since been used to develop 150 superior strains of crops and have yielded an extra 2,500 tons of grain. [Text] [Beijing XINHUA in English 0812 GMT 19 Sep 86 OW] /9738

COMPUTER SIMPLIFIES CHINESE CHARACTERS--Beijing, 2 Oct (XINHUA)--An engineer in China's Henan Province has developed a computer on which an operator can input even the most complicated Chinese characters by striking the keyboard just five times. The computer, designed by deputy chief engineer Wang Yongmin of the Henan Provincial Computer Center, can be used in news editing, publication and research, a spokesman for the center said today. The five main keys represent the five strokes used to make the thousands of characters that constitute Chinese writing. Some characters require only one stroke. Others use the same strokes in different places, requiring up to 15 or more movements. What makes this computer unique is that it can recognize even the most complicated characters after five strikes of the keyboard. "The operator can put a character with more than five strokes into the computer's memory just by typing the keys for its first four and last strokes," the spokesman said. "Anyone able to write Chinese characters can learn to type on the machine in ten minutes," he said adding that during one of his inspection tours of Henan in recent years, party leader Hu Yaobang input five Chinese characters into the machine. [Text] [Beijing XINHUA in English 1234 GMT 2 Oct 86 OW] /9738

CHINA'S FIRST OCEAN LABORATORY--Beijing, 3 Oct (XINHUA)--Work on China's first ocean laboratory simulating a marine environment has been finished in Qingdao City, in east China's Shandong Province, SCIENCE NEWS reports. This kind of laboratory used for marine studies previously existed only in Japan and the United States, the paper said. China started to build the laboratory at the end of last year with materials imported from Japan. The laboratory, 5 meters high and 16 meters in diameter, can endure high pressure and better simulate the actual marine environment than ordinary aquariums. Within its 300 cubic meters of water, rare fish and lobsters can be bred, the paper said. Visitors may see the "artificial ocean" through eight pieces of plexiglasses, each the size of a motion-picture screen. [Text] [Beijing XINHUA in English 1615 GMT 3 Oct 86 OW] /9738

JIANGSU HYDROCRACKING PLANT--Nanjing, 4 Oct (XINHUA)--An imported plant able to turn heavy oil into aviation fuel and fossil oil went into operation today at the Nanjing Oil Refinery, east China's Jiangsu Province. The hydrocracking installation will produce about 400,000 tons of quality aviation fuel and Diesel oil annually, yielding profits of 50 million yuan, an official of the plant said. [Text] [Beijing XINHUA in English 1602 GMT 4 Oct 86 OW] /9738

SHANGHAI FLOPPY DISK PRODUCTION--Shanghai, 29 Aug (XINHUA)--The quality of the first batch of floppy disks produced by China's largest production line in Shanghai is up to the ANSI (American National Standards Institute) standard and the world level, a local official said today. Imported from an American company, the line is able to produce annually 12 million sets of the disk; about 80 percent of them will be exported to Europe, the United States and Hong Kong. The line went into operation Thursday at the Huxing Electronics Company, a joint venture between Shanghai and Hong Kong. [Text] [Beijing XINHUA in English 1418 GMT 29 Aug 86 OW] /9738

NEW 16-BIT MICROCHIP--Shanghai, 13 Aug (XINHUA)--An integrated circuit used for the latest design of a 16-bit microcomputer passed certificate tests in this leading industrial city of China today. About the size of a soya bean, the circuit includes 17,500 mos transistors, nearly 40,000 lead-wire holes and a memory-control system. Developed by the Shanghai Metallurgical Research Institute, the CPU circuit can be used in automatic control and management computer systems and in space navigation. China expects to reduce imports of integrated circuits in the near future when the Lishan Microelectronics Industrial Company attached to the Ministry of Astronautics begins production. [Text] [Beijing XINHUA in English 1502 GMT 13 Aug 86 OW] /9738

HEBEI'S LARGEST ANTIBIOTICS PLANT--Shijiazhuang, 13 Sep (XINHUA)--The renovation of China's biggest antibiotic plant has passed state acceptance tests and will soon begin mass production to meet increasing domestic and foreign demand. The north China pharmaceutical factory, in Shijiazhuang, capital of Hebei Province, will turn out 458 tons of sodium penicillin a year, about one-sixth of China's present output. The renovation project began in 1981 and cost 70 million yuan (about 18.9 million U.S. dollars). It includes seven single projects for the fermentation and refinement of penicillin. China's largest antibiotics producer exports products to 25 countries and regions in addition to supplying domestic needs. Several of its main products, including sodium penicillin, glucose, have won state gold and silver medals for its high quality. [Text] [Beijing XINHUA in English 0202 GMT 13 Aug 86 OW] /9738

DOMESTIC TV PARTS--Beijing, 26 Aug (XINHUA)--Chinese television manufacturers have been reducing imported parts in their color sets thanks to progress within China's electronics industry, the overseas edition of the PEOPLE'S DAILY reported today. The communist party paper said most of the parts in domestic color television sets, video and tape recorders and computers are locally made and some are being exported. "This progress is a result of opening China to the outside world," the paper said. "We have been able to replace many old-fashioned machines with imported equipment that has enabled us to produce goods meeting international market standards." In addition, it said, better management of many of the country's factories has guaranteed a stable supply of reliable electronic components. [Text] [Beijing XINHUA in English 0535 GMT 26 Aug 86 OW] /9738

RESEARCH PATENTED ABROAD--Shanghai, 30 Sep (XINHUA)--Forty-nine universities in Shanghai have sold or are in the process of patenting research findings abroad, city education officials said today. Many of the 160 projects that sparked interest overseas were developed with foreign cooperation. These have included genetic research at Fudan University supported by a company manufacturing interferon in the United States, and development of a switching device at the Shanghai Railway College assisted by a Japanese company. Other joint research has involved computers and laser photocomposition. Working on their own, scholars in Shanghai have developed research to sell abroad. For example, the Huadong Chemical College has applied for patents in Japan and the United States for its new method of extracting citric acid from fermenting liquids. Some of the findings will be displayed in Guangzhou at the China Trade Fair, which begins in October. [Text] [Beijing XINHUA in English 0739 GMT 30 Sep 86 OW] /9738

CSO: 4010/2002

FORECASTING TYPHOON FORMATION, DEVELOPMENT IN SOUTH CHINA SEA

Beijing NANHAI HAIYANG KEXUE JIKAN [NANHAI STUDIA MARINA SINICA] in Chinese No 5, Apr 84 pp 99-109

[Article by Huang Zhixing [7806 1807 5281], Liu Jialing [0491 0857 3781], and Cheng Zhiqiang [4453 1807 1730] of the Chinese Academy of Sciences, South China Sea Institute of Oceanography, paper received 24 Jan 81; title footnoted as follows: This paper was checked by Professor Chen Shixun [7115 0013 6064] of the Zhongshan University Meteorology Department; Comrade Fan Shihung [4636 0013 3163] et al. assisted in arranging the data; for this we are grateful.]

[Text] The formation, development and movement of typhoons is an extremely complex problem. Tropical low pressure systems may or may not signal the development of a typhoon and its direction of movement, depending upon the interaction between the flow conditions at the periphery and the conditions at the interior of the low pressure system, and this is associated with the comprehensive effects of sea-air exchange, leading air currents, southwest monsoons, and cold air among other things.

To the present, both within and outside of China, there has been little study of forecasting methods for the formation and development of typhoons. In particular, forecasting methods for typhoon formation and development in the South China Sea are even more scarce. For the most part, the studies concentrate on analyses of the conditions of typhoon formation and development. Moreover, they are often limited to sample analyses.

The Hong Kong Meteorological Observatory's S.Y.W. Tse adopted the mathematical statistics method of forecasting. The crux of this method is to calculate the value of D in $D = \nabla_h^2(\psi_{250} - \psi750) - \nabla_h^2(\phi_{250} - \phi750)$, on the basis of a D value of the 6th degree, to differentiate between a low pressure system that will or will not develop into a typhoon, and the intensity of the development. But, this work does not include results from this method.

The Guangdong Meteorological Observatory and Zhongshan University jointly put forward a forecasting method which classifies the situation of the upper atmosphere 1 or 2 days prior to the formation of a typhoon to find dissimilar seasonal forecasting indications.

This work selects, among other things, the sea-air exchange intensity of sensible heat, the sea surface temperature, atmospheric stratification stability, the location of secondary high pressure systems, and the location (latitude) of cold air and low pressure systems (or typhoons) as forecasting factors, divides them into 3, 4 or 5 groups, and determines the weighted contribution of each group as to the formation and development of typhoons, whether or not they will land, and where they will land. Taking the factors two by two, we select the best combination of mutually effective average weights, utilize weighted addition, and, through step-by-step resolution, achieve forecasting results.

We carried out statistical analysis on 63 low pressure systems in the South China Sea (including low pressure systems moving into the South China Sea from the Pacific Ocean) from June to October in the years 1970 to 1979, as to whether or not they developed into typhoons; on 112 typhoons and low pressure systems (including typhoon moving into the South China Sea from the Pacific Ocean) as to whether or not they landed, either the location of landing or the direction of movement of the typhoons (low pressure systems) that did not land. Additionally, we tested and reported on 9 typhoons and low pressure systems from June to October in 1969 and 8 typhoons and low pressure systems from June to August in 1980 and the results were good.

I. Data and Forecasting Factors and Technological Specifications

1. Source of the Data

All the data used in this work was taken from 1970 to 1979 and represent ground level as well as 850, 700, and 500 millibars on the weather map, the "Typhoon Almanac," and the "Typhoon Route Map" of the Guangdong meteorological office.

2. The Reporting Line, the Forecasting Targets, and the Reporting Dates

The reporting line of typhoons (or low pressure systems) entering the South China Sea from the Pacific Ocean, as shown in the figure below, indicates the reporting line of tropical lows in the Pacific and formation of tropical lows in the South China Sea, and serves as a forecasting target for the formation and development of typhoons in the South China Sea. The reporting line of Pacific Ocean typhoons (or low pressure systems) and South China Sea typhoons (or low pressure systems) serves as a forecasting target for whether or not they will land, where they will land, and their direction of movement. The reporting date for Pacific Ocean typhoons (low pressure systems) is the date of entering the reporting line; the reporting date for South China Sea typhoons (low pressure systems) is the day of formation of the low pressure system.

3. Calculation of Factor Values

The key factors (Footnote 1) (Examples of the key meteorological factors at 0800 hours are the air temperature, sea surface temperature, wind, dewpoint, pressure change, location of secondary highs (latitude), apparent position-temperature relationship, etc.) on the day of the formation of the low pressure systems in the South China Sea or the day the center of Pacific Ocean typhoons (low pressure systems) enter the reporting line and the key factors of the previous day at 0800 hours are averaged.

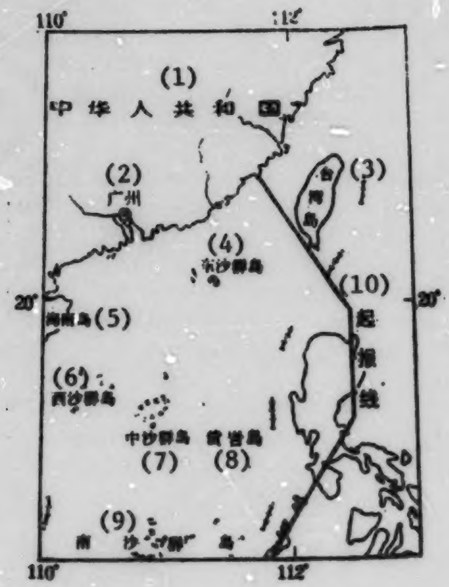

Figure 1. Map of the reporting line for Pacific Ocean typhoons and low pressure systems entering the South China Sea

Key:

1. People's Republic of China
2. Guangzhou
3. Taiwan
4. Dongsha Archipelago
5. Hainan Island
6. Xisha Archipelago
7. Zhongsha Archipelago
8. Huangyan Island
9. Nansha Archipelago
10. Reporting line

4. Selection of Forecasting Factors

The formation and movement of typhoons depend on the interaction of the interior conditions and the conditions on the periphery and are a result of the comprehensive effects of each forecasting factor.

Much research indicates that the effects of the ocean are extremely important to the formation and development of typhoons. High temperature sea surface can provide an unbroken supply of heat and water vapor to the lower atmospheric layers, influencing the air temperature and water vapor distribution of the lower layers due to the heat transport from the ocean to the atmosphere, and providing all the heat needed for a warm center in the course of forming a typhoon from a developing low pressure system. Therefore, the transport of sensible heat is the important energy source in the formation and development of typhoons.

Air convection from geopotential instability created by dissimilar thermal conditions is important, particularly with the appropriate incursion of cold air into the South China Sea, increasing the air pressure over the ocean, releasing baroclinic energy, raising the warm, moist air, and accelerating the developing convection. Other prevailing southwesterly air currents are strengthened in the lower layers of the atmosphere, accelerating the development of turbulence over the baroclinic line. Therefore, the latter has an equally stimulating effect on the formation and development of typhoons.

Secondary tropical high pressure systems in different locations form different flow environments, particularly when the secondary high pressure system and the typhoon (low pressure system) are located in a certain position. The easterly air current at the southern edge of the high pressure system has an effect on the formation and development of the typhoon, and can also determine the movement of the typhoon. But, when the typhoon or low pressure system is located in a different position (latitude and longitude), then the effects of the leading air current and other physical forces are not the same and have a close relationship with the movement of the typhoon.

Based on cyclone discovery concepts, typhoons move in the direction of greatest negative pressure change. Therefore, the pressure change of certain sites is one of the important signs of the development and movement of a typhoon.

According to theory, using the characteristic weather features on the following table gives clear meteorological concepts and, also, forecasting targets have more clearly causative forecasting factors:

X_1: The exchange intensity of sensible heat in the South China Sea, $Q = (T_w - T)V$, showing the sensible heat transfer from the ocean to the atmosphere. In the equation, T_w, T and V are the sea surface temperature at Xisha, the land surface temperature, and the wind velocity, respectively.

X_2: $\frac{1}{4} \sum_{\text{land}}^{\text{500 millibars}} (T - T_d)$ taking the temperature and average dewpoint values at the four levels (Xisha surface, 850, 700, and 500 millibars) and indicates the water vapor and temperature conditions of convection in the middle and lower layers.

X_3: The change in pressure over 24 hours in Guangzhou (Δp_{24}) to reflect the cold air activity.

X_4: $\Delta\theta_{sc} = \theta_{sc850} - \theta_{sc500}$ where θ_{sc850} and θ_{sc500} are the apparent position-temperature relationships of the Xisha site at 850 and 500 millibars, respectively, representing the thermal conditions of the two pressure levels.

X_5: The Xisha sea temperature, T_w, approximates the sea surface temperature of the South China Sea.

X_6: The latitude of tropical low pressure system formation in the South China Sea (or western Pacific low pressure systems and typhoons entering the reporting line).

X_7, X_8: Distinguish the line of secondary highs (latitude) and their westernmost point (longitude). (When the 588 line breaks into 2 loops, take the westernmost loop.)

X_9: $\frac{1}{3}(H^{500}_{Xisha} + H^{500}_{Fuzhou} + H^{500}_{Manila})$, where at the average altitude of 500 millibars at the 3 sites of Xisha, Fuzhou and Manila the intensity of the secondary high is indicated.

X_{10}: The wind direction at 700 millibars over Huzhiming city to indicate southwest monsoon activity.

X_{11}: $(T' - T)_{500}$ is the difference between the air temperature of the lower layers of Xisha from 850 to 500 millibars (T') and the surrounding temperature (T).

X_{12}: The 24 hour land surface pressure change at Xisha (Δp_{24}).

C: A correction factor. When there is a lack of ocean data, there are a few factors which allow use of Xisha data as representative; therefore, it is a measurement at a distance from Xisha which indicates typhoons (low pressure systems).

II. Steps of Weighted Addition

1. Forecasting factors based on the values from different forecasting targets are placed in a certain number of groups, the apparent parameter, F_{xij}, is determined from the calculations of forecasting targets in each group (where i is the sequence number of the factor, and j is the group indicator): the size of F_{xij} sets the weight of the forecasting target group contribution, A_{xij} (satisfying the condition F_{xij}/A_{xij} or $A_{xij}/F_{xij} \geq 0.5$).

2. Taking the factors two by two, select the optimum combination of mutually effective average weights, A_k:

$$A_k = \tfrac{1}{2}(Ax_{ij} + Ax_{i'j})$$

where x_i and $x_{i'}$ are a target factor combination and k is the combination sequence number.

3. Arrange a statistical table $S = \sum_{1}^{n} A_k + C$; n is based on the number of factor combinations of different forecasting targets taken two at a time, and C is the correction factor for each forecasting target.

4. Determine the critical value, y.

III. Predicting Whether Tropical Low Pressure Systems Will Develop Into Typhoons

1. Select the factors X_1, X_2, X_3, X_4, X_5, X_7, X_8, X_{10}, X_{11}, and X_{12}; comply with measure (1), (2) and enter into Table 1 (a), (b).....(f).

2. Calculate $S = \sum_{1}^{n} A_K + C$ and enter the result into Table 2.

3. Determine the critical value of S, $y = 2.7$. If $y > 2.7$, then the low pressure system will develop into a typhoon; if not, then the typhoon will not develop. Historically, the accuracy has been 63/63 = 100 percent.

From 1970 to 1979 during the months of June to October, 63 tropical low pressure systems have formed in the South China Sea (including those moving in from the Pacific). Of these, 37 have developed into typhoons.

Table 1(a). Effect of Factors X_1 and X_2 on the Average Weight A_1

A_1 Factor X_1 X_2		Group dist.	$X_1<0.5$	$0.5\leq X_1<3.5$	$3.5\leq X_1$
		wgt.	0.300	0.750	0.850
Group distribution	weight				
$4.5\leq X_2$	0.300		0.300	0.525	0.575
$3.0<X_2<4.5$	0.450		0.375	0.600	0.650
$X_2\leq 3.0$	0.800		0.550	0.775	0.825

Table 1(b). Effect of Factors X_4 and X_{11} on the Average Weight A_2

A_2 X_4 X_{11}		Group dist.	$X_4\leq 1$	$1<X_4<6$	$6\leq X_4$
		wgt.	0.400	0.500	0.600
Group distribution	weight				
$X_{11}<-0.5$	0.100		0.250	0.300	0.350
$-0.5\leq X_{11}\leq 0.5$	0.550		0.475	0.525	0.575
$0.5<X_{11}$	0.800		0.600	0.625	0.700

Table 1(c). Effect of Factors X_5 and X_{12} on the Average Weight A_3

A_3 X_5 X_{12}		Group dist.	$X_5<28.5$	$28.5\leq X_5\leq 29.0$	$29.0<X_5$
		wgt.	0.300	0.500	0.750
Group distribution	weight				
$0.5<X_{12}$	0.300		0.300	0.400	0.525
$-0.5\leq x_{12}\leq 0.5$	0.450		0.375	0.475	0.600
$X_{12}<-0.5$	0.850		0.575	0.675	0.800

Table 1(d). Effect of Factors X_7 and X_8 on the Average Weight A_4

A_4 X_7 X_8		Group dist.	$X_7<22$	$22\leq X_7\leq 28$	$28<X_7$
		wgt.	0.500	0.700	0.200
Group distribution	weight				
$120<X_8$	0.200		0.350	0.450	0.200
$100\leq X_8\leq 120$	0.500		0.500	0.600	0.350
$X_8<100$	0.700		0.600	0.700	0.450

Table 1(e). Effect of Factors X_3 and X_{10} on the Average Weight A_5

A_5 X_3 X_{10}		Group dist.	$X_3\leq 0$	$0<X_3\leq 1.5$	$1.5<X_3$
		wgt.	0.450	0.600	0.300
Group distribution	weight				
NNW $\frac{E}{\quad}$ SSE	0.300		0.375	0.450	0.300
S——SW	0.950		0.700	0.775	0.625
WSW $\frac{W}{\quad}$ NW	0.600		0.525	0.600	0.450

Table 1(f). Correction Factor, C

Distance (longitudinal) from Xisha	<3.0	3.0—6.0	6.0<
Correction factor	0.05	0.200	0.320

Table 2. Statistical Chart of Whether Tropical Low Pressure Systems Develop Into Typhoons

Sequence No.	Serial No.	Intensity	X_1/X_3	A_1	X_4/X_{11}	A_2	X_7/X_{12}	A_3	X_2/X_6	A_4	X_5/X_{10}	A_5	Ψ/C	S
1	70①	T	−1.9/4.4	0.375	4.5/0.9	0.650	29.2/−0.6	0.800	17.0/105.5	0.500	−0.1/NW	0.525	3.9/0.20	3.050
2	70②	L	3.0/3.8	0.600	3.5/0.3	0.525	28.5/0.9	0.400	20.3/128.5	0.350	−0.2/WNW	0.525	1.0/0.05	2.450
3	70③	L	10.0/3.3	0.650	5.5/0.5	0.525	29.3/1.2	0.525	21.6/104.5	0.500	1.9/WSW	0.450	2.3/0.05	2.700
4	70[illegible]	L	−1.8/4.9	0.300	0.5/−1.3	0.250	29.4/−0.8	0.800	28.7/103	0.350	−0.1/WSW	0.525	4.2/0.20	2.425
5	70[illegible]	L	3.3/2.5	0.775	4.5/1.6	0.650	28.2/0.7	0.300	32.4/121	0.200	1.0/W	0.600	1.0/0.05	2.575
6	70[illegible]	L	1.3/5.3	0.525	5.5/0.1	0.525	28.2/−0.1	0.375	28.5/100.5	0.350	−1.3/NNE	0.375	5.5/0.20	2.350
7	7012	T	0.5/3.8	0.600	2.0/−0.4	0.525	27.4/0.9	0.300	23.2/98	0.700	0.3/SE	0.450	5.7/0.20	2.775
8	70[illegible]	L	−6.2/4.8	0.300	2.5/−1.4	0.300	27.3/1.5	0.300	21.8/109	0.500	2.7/W	0.450	9.7/0.32	2.170
9	70[illegible]	L	−0.4/5.1	0.300	3.5/−1.4	0.300	27.9/−1.3	0.575	28.2/109	0.350	−1.4/N	0.375	9.7/0.32	2.220
10	71[illegible]	L	−1.2/4.4	0.375	2.5/1.3	0.650	27.5/0.0	0.375	19.3/108	0.500	−1.7/ESE	0.375	9.7/0.32	2.595
11	71[illegible]	L	−4.3/5.3	0.300	3.5/0.3	0.525	28.0/1.1	0.300	23.5/109.5	0.600	2.2/NW	0.450	5.4/0.20	2.375
12	71[illegible]	L	−5.1/4.1	0.375	7.5/1.4	0.700	28.0/−1.0	0.575	32.2/127	0.200	−1.5/W	0.525	10.3/0.32	2.695
13	7112	T	−1.4/5.6	0.300	8.5/0.8	0.700	27.5/1.2	0.300	27.7/117	0.600	1.6/SW	0.625	7.1/0.32	2.825
14	71[illegible]	L	0.3/11.3	0.300	9.0/−1.6	0.350	29.2/−0.5	0.600	34.9/111	0.350	−0.7/SW	0.700	6.2/0.32	2.620
15	71[illegible]	L	0.2/4.8	0.300	−2.0/−1.4	0.250	28.4/1.1	0.300	24.1/126	0.450	1.2/SSW	0.775	3.6/0.20	2.275
16	72[illegible]	T	0.4/4.4	0.375	6.5/0.9	0.700	28.7/−0.8	0.675	21.9/105	0.500	1.1/NW	0.600	4.2/0.20	3.050
17	72⑦	L	−3.9/3.3	0.375	7.0/1.7	0.700	28.4/0.8	0.300	17.6/123	0.350	1.6/SW	0.625	9.7/0.32	2.670
18	72[illegible]	L	0.2/4.9	0.300	2.0/−1.3	0.300	28.8/−0.2	0.475	26.3/112.5	0.600	0.0/W	0.525	2.5/0.05	2.250
19	7204	T	−0.7/5.5	0.300	6.5/−0.01	0.575	28.8/−0.6	0.675	28.6/106	0.350	0.3/W	0.600	9.7/0.32	2.820
20	7210	T	1.6/3.9	0.600	4.0/0.8	0.650	29.0/0.1	0.475	26.2/105	0.600	0.3/WNW	0.600	10.0/0.32	3.245
21	7211	T	−0.9/4.2	0.375	4.0/0.6	0.650	27.7/1.3	0.300	28.6/107	0.350	1.5/SW	0.775	8.5/0.32	2.770
22	7212	T	0.4/4.5	0.300	5.0/−0.5	0.525	27.2/−0.4	0.375	22.7/103.5	0.600	−1.0/SSW	0.700	10.0/0.32	2.820
23	7216	T	−0.1/3.4	0.375	8.0/2.1	0.700	28.5/0.5	0.475	23.6/88	0.700	1.4/ENE	0.450	5.0/0.20	2.900
24	7301	T	3.1/7.3	0.525	4.5/−1.5	0.300	30.1/−0.4	0.600	25.9/110.5	0.600	1.3/E	0.450	9.7/0.32	2.795
25	7302	T	4.0/7.1	0.575	7.5/0.3	0.575	30.5/−0.8	0.800	19.2/124.5	0.350	−2.4/WSW	0.525	6.2/0.32	3.145
26	7304	T	2.9/4.0	0.600	3.0/0.2	0.525	29.2/0.5	0.600	26.2/116	0.600	0.2/WSW	0.600	4.2/0.20	3.125
27	7307	T	2.5/2.8	0.775	2.5/0.8	0.650	29.8/0.3	0.600	33.1/105	0.350	1.0/ESE	0.450	10.0/0.32	3.145
28	7311	T	3.1/3.3	0.600	4.3/1.7	0.650	29.2/−1.1	0.800	33.7/91	0.450	0.0/W	0.525	9.7/0.32	3.345
29	7312	T	8.2/2.4	0.825	−1.0/0.0	0.475	29.1/0.8	0.525	31.3/97	0.450	0.0/SW	0.700	1.0/0.05	3.025
30	73[illegible]	L	0.0/4.6	0.300	5.5/−0.2	0.525	29.4/0.5	0.600	21.8/100	0.500	1.4/SE	0.450	3.8/0.20	2.575
31	7316	T	2.1/2.8	0.775	8.0/3.3	0.700	28.7/−0.5	0.475	28.2/89	0.450	0.4/E	0.450	5.0/0.20	3.050
32	74[illegible]	T	8.8/5.4	0.575	4.0/0.4	0.525	29.3/−1.2	0.800	21.3/120.5	0.350	1.8/WNW	0.450	1.5/0.05	2.750

[Continued on following page]

Sequence No.	Serial No.	Intensity	X_4/X_5	A_1	X_6/X_{11}	A_2	X_7/X_{12}	A_3	X_2/X_3	A_4	X_8/X_{10}	A_5	J**/C	S
33	7412	T	0.6/5.1	0.525	−0.5/−2.0	0.250	29.5/−1.8	0.800	30.5/116	0.350	−1.8/WSW	0.525	6.6/0.32	2.770
34	74[illegible]	T	27.8/4.0	0.650	5.5/0.4	0.525	29.5/−1.5	0.800	34.9/131	0.200	−0.4/NW	0.525	4.0/0.20	2.900
35	7417	T	2.5/3.6	0.775	0.5/−0.2	0.475	28.7/1.1	0.400	18.5/130	0.350	0.6/SW	0.775	5.9/0.20	2.975
36	7419	T	−0.9/5.0	0.300	4.5/0.3	0.525	28.0/0.2	0.375	26.7/140	0.450	0.2/SSW	0.775	7.1/0.32	2.745
37	75[illegible]	L	0.7/4.5	0.525	1.5/−0.7	0.300	29.7/−0.2	0.600	21.3/126	0.350	1.4/WNW	0.600	4.5/0.20	2.575
38	7504	T	−2.5/3.9	0.375	10.0/2.4	0.700	29.0/−1.5	0.675	28.2/112	0.350	0.6/W	0.600	3.9/0.20	2.900
39	75[illegible]	L	−7.2/6.2	0.300	7.5/−0.4	0.575	28.4/−0.4	0.375	26.6/109	0.600	−1.1/WNW	0.525	9.2/0.32	2.695
40	75[illegible]	T	3.3/3.1	0.600	3.5/1.6	0.650	28.0/1.4	0.300	37.2/91	0.450	1.4/SW	0.775	1.5/0.05	2.825
41	75[illegible]	L	−0.3/6.6	0.300	7.0/−0.2	0.575	27.9/−1.3	0.575	33.6/110	0.350	−1.0/WNW	0.525	5.8/0.20	2.525
42	7513	T	1.4/6.1	0.525	3.5/−1.5	0.300	28.9/−0.7	0.675	26.2/96	0.700	0.1/SW	0.775	7.8/0.32	3.295
43	7515	T	3.9/3.1	0.650	−0.5/−0.4	0.475	27.4/−1.9	0.575	21.6/125	0.350	−1.9/W	0.525	9.7/0.32	2.895
44	76[illegible]	L	−0.5/4.5	0.300	3.0/−4.0	0.300	28.9/0.3	0.475	22.5/117	0.600	0.8/WSW	0.600	1.0/0.05	2.325
45	7610	T	1.4/10.8	0.525	7.0/−3.0	0.350	28.9/−0.7	0.675	26.0/116	0.600	0.1/W	0.600	4.9/0.20	2.950
46	7614	T	−1.1/3.8	0.375	1.5/0.0	0.525	28.4/−0.8	0.575	29.6/106	0.350	−0.7/SW	0.700	4.5/0.20	2.725
47	7619	T	2.5/5.9	0.525	−2.5/−3.9	0.250	28.7/−1.1	0.675	24.8/92	0.700	−0.3/W	0.525	2.0/0.05	2.725
48	7701	T	−2.5/7.6	0.300	7.5/0.9	0.700	29.4/−1.3	0.800	21.6/107	0.500	1.1/SE	0.450	0.2/0.32	3.070
49	7702	T	0.3/5.3	0.300	4.0/−1.1	0.300	29.7/−1.9	0.800	27.1/113	0.600	−1.0/WNW	0.525	3.0/0.20	2.725
50	7709	T	−0.4/3.5	0.375	2.5/0.3	0.525	28.8/−2.0	0.675	25.3/105	0.600	−1.3/W	0.525	9.7/0.32	3.020
51	78[illegible]	L	3.0/3.5	0.600	−0.5/−0.6	0.250	29.0/−1.3	0.675	29.7/113	0.350	0.6/WNW	0.600	5.1/0.20	2.675
52	7804	T	−2.2/6.8	0.300	0.5/−0.2	0.575	28.8/3.1	2.400	25.8/100	0.600	−4.7/SSW	0.700	9.7/0.32	2.895
53	7807	T	2.0/3.0	0.775	0.5/0.1	0.475	29.5/−1.4	0.800	34.2/110	0.350	−0.4/W	0.525	1.0/0.05	2.975
54	7809	T	22.3/2.2	0.825	−0.5/−0.5	0.475	29.3/3.9	0.525	33.7/110	0.350	−1.2/WNW	0.525	3.0/0.20	2.900
55	78[illegible]	L	−0.2/4.5	0.300	1.0/0.0	0.475	28.6/1.2	0.400	32.8/113	0.350	−0.8/WNW	0.525	7.8/0.32	2.370
56	78[illegible]	L	1.3/3.7	0.600	1.0/−0.9	0.250	28.9/0.9	0.400	28.8/103	0.350	1.1/S	0.775	6.4/0.32	2.695
57	78[illegible]	L	0.8/4.6	0.525	1.5/−1.2	0.300	28.1/−0.8	0.575	28.2/100	0.350	−0.7/W	0.525	9.7/0.32	2.595
58	78[illegible]	T	0.7/2.4	0.775	−4.5/−1.5	0.250	26.5/2.3	0.300	26.4/103	0.600	−0.4/S	0.700	10.0/0.32	2.945
59	79[illegible]	L	2.9/5.0	0.525	4.0/−0.9	0.300	30.2/−0.3	0.600	26.6/93	0.700	−0.3/SE	0.375	4.5/0.20	2.700
60	79[illegible]	L	3.3/3.8	0.600	2.5/0.2	0.525	29.9/2.3	0.725	29.9/72	0.450	6.8/W	0.450	2.4/0.05	2.600
61	79[illegible]	T	5.9/2.3	0.825	6.5/2.5	0.700	29.8/−0.4	0.600	28.4/85	0.450	−0.2/SE	0.375	0.5/0.05	3.000
62	7918	T	3.6/6.4	0.575	1.5/−3.6	0.300	27.8/0.0	0.375	22.4/9.0	0.700	−1.3/NW	0.525	6.5/0.32	2.795
63	79[illegible]	L	4.2/9.8	0.575	−4.0/6.4	0.250	26.9/0.01	0.375	28.2/134	0.200	−0.8/NE	0.375	6.1/0.32	2.095

*"70 ③" indicates the 3d typhoon of 1970, "7012" indicates the 12th typhoon of 1970.

**refers to the distance from the Xisha site of typhoons (low pressure systems) entering the reporting line from the Pacific and low pressure systems forming in the South China Sea.

Key: Under "Intensity" column: T = typhoon, L = low pressure system

IV. Predicting the Direction of Movement of Typhoons and Low Pressure Systems

From 1970 to 1979, during the months of June to October, there were 112 typhoons and low pressure systems in the South China Sea (including those moving in from the Pacific); of these, 60 landed (east to Huian, Fujian; the others did not land). Of those that landed, there were 16 at Aodong (east of 114°E), and 44 at Aoxi (west of 114°E). Of the 52 that did not land, 9 moved east to 120°E, 10 dispersed at sea, and 33 moved west to Vietnam and the northern section of the bay.

1. Predicting Whether a Typhoon Will Land

The effects of the direction of motion of typhoons or low pressure systems and their positions (latitude, the leading air currents, cold air, and southwesterly air currents are closely related. Select the factors X_1, X_3, X_5, X_6, X_7, X_8, X_{10}, and X_{12} according to measures (1) and (2) and complete Table 3 (a), (b).....(e).

Table 3(a). Effect of Factors X_1 and X_5 on the Average Weight A_6

A_6 X_1 X_5		Grp. dist.	$X_1<-3.5$	$-3.5\leq X_1\leq 0$	$0<X_1<2.0$	$2.0\leq X_1<5.0$	$5.0\leq X_1$
		wgt.	0.200	0.400	0.650	0.700	0.900
Group dist.	weight						
$X_5<27.0$	0.200		0.200	0.300	0.425	0.450	0.550
$27.0\leq X_5\leq 28.0$	0.350		0.275	0.375	0.500	0.525	0.625
$28.0<X_5<29.0$	0.500		0.350	0.450	0.575	0.500	0.700
$29.0\leq X_5\leq 29.5$	0.600		0.450	0.500	0.625	0.650	0.750
$29.5<X_5$	0.750		0.475	0.575	0.700	0.725	0.825

Table 3(b). Effect of Factors X_3 and X_{10} on the Average Weight A_7

A_7 X_3 X_{10}		Grp. dist.	$X_3>2.0$	$2.0\geq X_3\geq 1.0$	$1.0>X_3\geq -0.5$	$-0.5>X_3\geq -1.5$	$-1.5>X_3$
		wgt.	0.300	0.400	0.500	0.600	0.650
Group dist.	weight						
NW-NNE	0.200		0.250	0.300	0.350	0.400	0.425
NE-E	0.450		0.375	0.425	0.475	0.525	0.550
ESE-S	0.400		0.350	0.400	0.450	0.500	0.525
SSW-WSW	0.600		0.450	0.500	0.550	0.600	0.625
W-WNW	0.700		0.500	0.550	0.600	0.650	0.675

Table 3(c). Effect of Factors X_7 and X_8 on the Average Weight A_8

A_8 X_7 X_8	Grp. dist	$X_7<21$	$21\leq X_7<24$	$24\leq X_7\leq 29$	$29<X_7<32$	$32\leq X_7$
	wgt.	0.400	0.600	0.700	0.900	0.350
Group dist.	weight					
$X_8<104$	0.30	0.350	0.450	0.500	0.600	0.325
$104\leq X_8\leq 110$	0.60	0.500	0.600	0.650	0.750	0.475
$110<X_8<115$	0.70	0.550	0.650	0.700	0.800	0.525
$115\leq X_8\leq 121$	0.75	0.575	0.675	0.725	0.825	0.550
$121<X_8$	0.20	0.300	0.400	0.450	0.550	0.275

Table 3(d). Effect of Factors X_6 and X_{12} on the Average Weight A_9

A_9 X_6 X_{12}	Grp. dist	$X_6<12$	$12\leq X_6\leq 15$	$15<X_6\leq 18$	$18<X_6\leq 21$	$21<X_6$
	wgt.	0.150	0.350	0.550	0.600	1.000
Group dist.	weight					
$1.0\leq X_{12}$	0.35	0.250	0.350	0.450	0.475	0.675
$0\leq X_{12}<1.0$	0.40	0.275	0.375	0.475	0.500	0.700
$-1.0\leq X_{12}<0$	0.50	0.325	0.425	0.525	0.550	0.750
$-1.5\leq X_{12}<-1.0$	0.70	0.425	0.525	0.625	0.650	0.850
$-1.5>X_{12}$	0.75	0.450	0.550	0.650	0.675	0.875

Table 3(e). Correction Factor, C

Distance (longitudinal) from Xisha	<4.0	4.0–8.0	8.0<
Correction factor	0.05	0.100	0.275

Fill in each calculated value of S on a statistical chart of whether the typhoon or low pressure system lands.

Determine the critical value $y = 2.2$. If $y \geq 2.2$, then the typhoon (low pressure system) lands; if not, it does not land.

Historically, the accuracy has been 95/112 = 84.8 percent.

2. Predicting the Location of Landing

To determine the landing location of the 60 typhoons and low pressure systems which landed, select the factors X_1, X_6, X_7, X_8, X_9, and X_{10} and complete the squares on the following table (Table 4).

Table 4(a). Effect of Factors X_1 and X_9 on the Average Weight A_{10}

A_{10} X_1 X_9		Group dist.	$X_1 \leq -1.5$	$-1.5 < X_1 < 1.0$	$1.0 \leq X_1 \leq 5.0$	$5.0 < X_1$
		wgt.	0.750	0.600	0.500	0.400
Group dist.	weight					
$X_9 < 584$	0.300		0.525	0.450	0.400	0.350
$584 \leq X_9 < 586$	0.600		0.675	0.600	0.550	0.500
$586 \leq X_9 < 588$	0.350		0.550	0.475	0.425	0.375
$588 \leq X_9$	0.000		0.375	0.300	0.250	0.200

Table 4(b). Effect of Factors X_7 and X_8 on the Average Weight A_{11}

A_{11} X_7 X_8		Group dist.	$X_7 \leq 22$	$22 < X_7 < 25$	$25 \leq X_7 < 29$	$29 \leq X_7$
		wgt.	0.850	0.300	0.500	0.600
Group dist.	weight					
$X_8 \leq 104$	0.400		0.625	0.350	0.450	0.500
$104 < X_8 < 115$	0.550		0.700	0.425	0.525	0.575
$115 \leq X_8 \leq 120$	0.700		0.775	0.500	0.600	0.650
$120 < X_8$	0.300		0.575	0.300	0.400	0.450

Table 4(c). Effect of Factors X_{10} and X_6 on the Average Weight A_{12}

A_{12} X_{10} X_6		Group dist.	W-WNW	NW-NE	ENE-S	SSW-WSW
		wgt.	0.300	0.800	0.550	0.500
Group dist.	weight					
$X_6 < 15$	0.400		0.350	0.600	0.475	0.450
$15 \leq X_6 \leq 17$	0.450		0.375	0.625	0.500	0.475
$17 < X_6 \leq 20$	0.700		0.500	0.750	0.625	0.600
$20 < X_6$	0.750		0.525	0.775	0.650	0.625

Table 4(d). Correction Factor, C

Distance (longitudinal) from Xisha	<5.0	5.0—7.0	>7.0
Correction factor	0.1	0.08	0.05

Fill in each calculated value of S on a statistical chart of the location of the landing of the typhoon or low pressure system.

Determine the critical value y = 1.7. If $y \geq 1.7$, then the typhoon (low pressure system) lands in Aodong; if not, it lands in Aoxi.

Historically the accuracy has been 56/60 = 93.3 percent.

3. Predicting the Direction of Motion of Typhoons and Low Pressure Systems That Do Not Land

Whether the typhoon moves east, west or disperses at sea depends on factors of atmospheric energy and cold air and the westernmost position of secondary highs. Select the factors X_1, X_5, X_6, and X_8 and differentiate among the 52 typhoons and low pressure systems that did not land as to whether they moved east or west (including those that dispersed at sea). Arrange them in a chart to carry out statistics, calculate the resulting critical value $y = 1.3$. If $y \geq 1.3$, then the typhoon (low pressure system) is of the east moving type; if not, it is of the west moving type. Historically, the accuracy has been 50/52 = 96.2 percent. Then, select the factors X_2, X_3, X_5, and X_{12} and differentiate among the 43 typhoons and low pressure systems as to whether they move west or disperse at sea. Arrange them in a chart to carry out statistics and calculating the resulting critical value $y = 1.3$. If $y \geq 1.3$, the typhoons (low pressure systems) disperse at sea; if not, they move west to 110°E. Historically, the accuracy has been 39/43 = 90.6 percent.

V. Testing and Reporting Results

1. Forecasting Procedure

Each time a tropical low pressure system forms in the South China Sea or enters the reporting line of the western Pacific, first find each factor value from Table 1, and from the table calculate a value for S, to predict whether it will develop into a typhoon. The second step is to find the factor values from Table 3, calculate a value for S, and predict whether it will land. Finally, statistically, calculate a value for S, and determine the location of landing and predict the direction of motion of the typhoons (low pressure systems) that do not land.

2. Testing and Reporting Results

We carried out testing and verification on 9 typhoons and low pressure systems which occurred from June to October 1969; their average accuracy was 89.9 percent. We tested and reported on 8 typhoons and low pressure systems from June to August 1980. The accuracy of whether or not they would develop into typhoons was 87.5 percent; forecasting accuracy of the direction of movement of typhoons (low pressure systems) that did not land was 100 percent. Average accuracy was 93.3 percent (see Table 5).

VI. Brief Summary

The methods and results of the steps presented in this work to predict the formation and direction of motion of typhoons have many problems that merit investigation.

Table 5. Comprehensive Forecasting of the Formation and Development of Typhoons (Low Pressure Systems) From June to August 1980, Using the Weighted Addition Method

	Whether it develops into a typhoon			Whether it lands			Where it lands			Direction of movement of typhoons (low pressure) that do not land						Average accuracy
										Direction category			West or disperse			
Typhoon Serial No.	Forecast	Actual	Acc	Fore.	Actual	Acc	Fore.	Actual	Acc	Fore.	Actual	Acc	Fore.	Actual	Acc	
8005	Develop	Typhoon	0	Land	Landed	0	Aoxi	Hainan	0							
South China Sea low pressure (6.30-7.2)	Not develop	Low pressure	0	Not land	Not landed	0				West moving	Dispersed	0	Disperse	Dispersed	0	
8006	Develop	Typhoon	0	Land	Landed	0	Aodong	Swatow	0							
8008	Develop	Typhoon	0	Land	Landed	0	Aoxi	Yangjiang	0							
8007	Develop	Typhoon	0	Land	Landed	0	Aoxi	Xuwen	0							
8009	Develop	Typhoon	0	Land	Landed	0	Aoxi	Lufeng	X							
8011	Develop	Typhoon	0	Land	Landed	0	Aoxi	Dianbai	0							
South China Sea low pressure (8.27-31)	Develop	Low pressure	X	Land	Landed	0	Aoxi	Yaxian	0							
Accuracy	87.5 percent			100 percent			85.7 percent			100 percent						93.3 percent

Note: "0" indicates forecasting accuracy; "X" indicates forecasting error.

1. This work used the key factors of the day and the day before a tropical low pressure system formed in the South China Sea (or when a typhoon or low pressure system from the Pacific Ocean entered the reporting line), and did not consider the route and seasonal conditions of the typhoons (or low pressure systems), to more directly forecast the formation, development and landing of the typhoon. We do not forecast the speed with which the typhoon develops or the speed of movement. This needs continued research.

2. The weighted contribution of each of the forecasting targets and forecasting factors used in this method were rationally decided upon, and we consider the formation and development of the typhoon is the comprehensive result of many mutually effective factors. Thus, more objectivity will produce more ideal forecasting. But, how to use more suitable factors as the key elements influencing the forecasting targets is deserving of deep research.

3. In the mathematical statistics of forecasting, the selection of the forecasting factors is a problem deserving of deep investigation. Although the factors selected in this work can indicate certain weather characteristics, and can also clarify meteorological concepts, and their forecasting targets are also closely associated with physical processes, however, due to deficiencies in current data, a small representative surface is, in the final analysis, inadequate for success.

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PHYSICAL SCIENCES

USE OF AOU IN MIDDLE, DEEP WATER CIRCULATION IN SOUTH CHINA SEA

Beijing NANHAI HAIYANG KEKUE JIKAN [NANHAI STUDIA MARINA SINICA] in Chinese No 5, Apr 84 pp 139-152

[Article by Wu Linxing [0702 2651 5281] of the Chinese Academy of Sciences, South China Sea Institute of Oceanography; paper received 15 Mar 81]

[Text] For technological reasons, direct determination of water circulation in the middle and deep layers of the sea is very difficult. Generally, high level dynamic calculations are adopted and combined with estimations based on chemical parameters (for example, C^{14} and O_2). A description of circulation in the South China Sea was given in a NAGA report by Wyrtki[3] (1960). Zhu Zuyou [4281 4371 0147][1] (1972) also discussed circulation in the Bashi Channel in an article in "Exchange in Water Flows Between the Pacific Ocean and the South China Sea." They consistently consider that the deep water of the Pacific passes through the Bashi Channel and enters the South China Sea while the surface layer flow is greatly influenced by the monsoons. This work utilizes A.O.U. [apparent oxygen utilization] in a preliminary inquiry of the circulation patterns in the middle and deep water layers of the South China Sea.

I. Principles

Experimental data from several voyages make clear that the lowest salt content of the South China Sea is in the middle layer, centered at a depth of approximately 500 meters. But, below 1200 meters, the water composition is very evenly distributed, the water temperature in the deep layers of the Pacific is lower by 4°C, and the salt content is between 34.50 and 34.60 per thousand. This work assumes water at a depth of approximately 500 meters to be representative of the middle layer. Because the data from depths greater than 1200 meters is relatively sparse, water at approximately 1200 meters is taken to be the deep layer. The average value of σ_t at 500 meters is 26.79 and at 1200 meters it is 27.50.

II. Data

The South China Sea Institute of Oceanography of the Chinese Academy of Sciences "Shi Yan Hao" in June and July of 1978 and June and July of 1979 differentiated between the middle section and the northeast section of the South China Sea and researched those ocean areas obtaining a large amount of data. The summer circulation situation discussed in this work is based principally on the data from these two voyages. In addition, some data was used from the National Oceanographic Office "Xiang Yang Hong #3" in July 1976, in the ocean areas north of the Xisha and Zhongsha Archipelagos (for middle layer data only) and Taiwan University "Li Lian Hao" in August 1971 in the eastern areas of the South China Sea near the Philippines. In order to make up for the shortcoming in data for this season in ocean areas in the vicinity of the Zhongsha and Xisha Archipelagos, relevant data from the South China Sea Institute of Oceanography of the Chinese Academy of Sciences "Hong Qi #088" in May 1976, in research on this ocean area was referenced. Figure 1 shows the path of each voyage.

III. Results

Differentiation between the σ_t values at 500 and 1200 meters in the central section of the South China Sea (Figures 2 and 3) and the temperature, salt content, and A.O.U. value distribution lines of the σ_t 26.79 and σ_t 27.50 surfaces (Figures 4-9) are shown. Figures 10 and 11 are diagrams of the circulation in these two surfaces (the thickness of the front indicates the intensity of the circulation).

The A.O.U. distribution curve clearly indicates that the fundamental trends at the two surfaces with σ_t values of 26.79 and 27.50 are the same. In the eastern ocean areas, it progressively increases from north to south. At the entrance to the Bashi Channel, between 20° and 22°N there is a tongue of low A.O.U. value water which extends to the vicinity of the Dongsha Archipelago. But, the A.O.U. values at the southern tip of the Dongsha Archipelago are high compared to the southwestern areas which are even more southern. In other words, north of the Dongsha and the Xisha Archipelagos, at 18°N, 114°E, is the center of low A.O.U. values. Off the western coast of Luzon Island in the Philippines, there is also an area of high A.O.U. values (in the vicinity of 17°N, 119°E). To the south of the Xisha Archipelago, the A.O.U. values again progressively increase in the direction of the Vietnam coast. Moreover, in the southeast, near the entrance to the Sulu Sea between Mindoro Island and Palawan Island, the A.O.U. value is relatively low.

IV. Discussion

Increases in A.O.U. value indicate the direction of water movement as the water goes from "young" to "old" as more biological oxidation occurs. However, we are still unable to provide the distinction between advection and mixing processes since A.O.U. is not only related to biological oxidation, but also is affected by mixing. Because of this, discrepancies in the productive forces of the surface layer could also give rise to discrepancy in the oxidation rate in the deep layers.

Regarding the distinction between advection and mixing processes, we can analyze parameters on a σ_t surface such as salt content and temperature. These parameters are only affected by runoff, precipitation and water mixing, and are not affected by biological activity.

From the distribution lines for salt and temperature and other parameters of the two σ_t surfaces, we can see that the water is relatively stable. On the 26.79 σ_t surface from the entrance to the Bashi Channel to the southeast section of the Dongsha Archipelago and heading south (slightly to the southwest) to the middle of the broad ocean area, the temperature is between 8.30 and 8.40°C and the salt content is 34.42 to 34.44 per thousand. This is extremely consistent with the indication of current direction by the A.O.U. level. Moreover, at the northern section of the Zhongsha Archipelago, at 114°E, 18°N, there is a center of high salt and high water temperature, its temperature and salt level each progressively decrease in a northeasterly direction until it reaches the southern side of the Dongsha Archipelago. This is also the direction of progressively increasing A.O.U. levels. On the 27.50 σ_t surface, the temperature and salt distribution is relatively even. Temperatures are generally from 3.50 to 3.70°C. Salt contents are between 34.55 and 34.57 per thousand. We do not see evidence that very turbulent vertical mixing is taking place.

Zhu Zuyou[1], in his discussion of the exchange of waters of the Pacific Ocean and the South China Sea, used the trigonal method of mixing to calculate the main composition of black tide water, middle layer water, and deep layer water from the Pacific Ocean in the surface, middle and deep layer waters at each site of the South China Sea. For example, at 11°27.1'N, 114°12.1'E, the black tide water in the surface layer (σ_t 25.5) was 54 percent, Pacific Ocean middle layer water in the middle layer (σ_t 26.5-27.0) was 58-70 percent, at σ_t 26.79 it was 64 percent, and in the deep layer (σ_t 27.50) the Pacific Ocean deep layer water was 78 percent. In other words, from the entrance of the Bashi Channel, after flowing southwest for more than 1,000 km, the water originating in each layer of the Pacific Ocean makes up more than half the total. Moreover, at increasing depths, the influence of the mixing effect becomes increasingly small. Therefore, at the two levels of σ_t 26.79 and σ_t 27.50, the A.O.U. basically indicates the direction of water movement.

In addition, one can carry out analysis from the density distribution. H.U. Sifeidelupu [2448 6316 1795 7627 2528] et al.[2] point out, in the northern hemisphere "where there are sea currents, relatively low density sea water is located on the right side of the direction of current and relatively high density sea water is on its left." Figures 2 and 3 show the density at 500 and 1200 meters; at the entrance to the Bashi Channel it is roughly low in the north and high in the south and the current flows from east to west. Also, the sea surface at the eastern section of ocean south of the Dongsha Archipelago basically has a density which is high in the east and low in the west and the current flows from north to south. In the southern section of the Xisha Archipelago, from 113°E and west, just opposite the eastern section, the density at 500 meters progressively increases as one goes west and the current flows from south to north. This is basically consistent with the A.O.U. values which indicate that the direction of the sea current is toward the Vietnam coast. Moreover, in the northern section of central Xisha Archipelago, from 18°N, 114°E, northeast to the southern tip of the Dongsha Archipelago, it can also be seen that its density appears high in the northwest and southeast sections, and the sea current appears to be in a northeasterly direction. This appears to be consistent with the direction of circulation as indicated by the A.O.U. values. Additionally, on the western coast of Luzon Island in the Philippines and near the entrance to the Sulu Sea there is a similar situation. The density at 1200 meters near the Vietnam coast is similar to that in the eastern ocean areas. It is possible that the circulation in this area is weaker. This is a similar situation to that at 500 meters and other levels.

Zhong Huanliang [6988 2970 5328] (Footnote 1) (Zhong Huanliang, 1979, preliminary investigation of circulation in the northern ocean area of the Zhongsha and Xisha Archipelagos, Ocean Scientific and Technological Data, No 7, pp 1-23, National Oceanographic Office Ocean Scientific and Technological Information Research Institute) (1979) used high level dynamics to calculate the circulation in the ocean area north of the Zhongsha and Xisha Archipelagos. He discovered a water layer with inverted circulation at 400 meters. The direction of current in the vicinity of 18°N, 114°E is quite similar to the direction of current in our σ_t 26.79 surface (Figure 12). Xu Xizhen [1776 6932 4394] (Footnote 2) (Xu Xizhen, 1978, middle layer of the South China Sea circulation and exchange with outside waters, unpublished) (1978) described the winter and summer patterns of circulation in the middle layer (500 meters) of the South China Sea based on the isobath distribution and other hydrologically important distributions of the σ_t surface. The closed horizontal circulation in the summer is of the anticyclone type (Figure 13). The indication of A.O.U. values in the present work is basically similar to this circulation pattern. Only near the eastern Philippine coast are there indication of weak flow in the direction of the coast according to A.O.U. values. It is possible that nutrients are relatively abundant near the coast giving rise to high A.O.U. values or the GM-85 model oxygen analyzer used by "Jiu Lian Hao" gave oxygen measurements with consistently low bias giving rise to deviations in the A.O.U. computations. However, there is the data report that the flow is increased here and, thus, the flow direction affects the horizontal circulation.

There is no additional data for comparison with the deep water layer data. However, going through a few conservative composition and density analyses, we could consider that the A.O.U. levels all basically indicate that the deep layer circulation is generally stable.

Of course, since we failed to carry out simultaneous observations and also since all data we used was taken at the same time of the month, and there was a definite time interval, adding different observations using different methods to obtain data discrepancies, calculation results cannot avoid having certain errors. Because of this, the circulation directions as indicated in this work by A.O.U. are relatively crude.

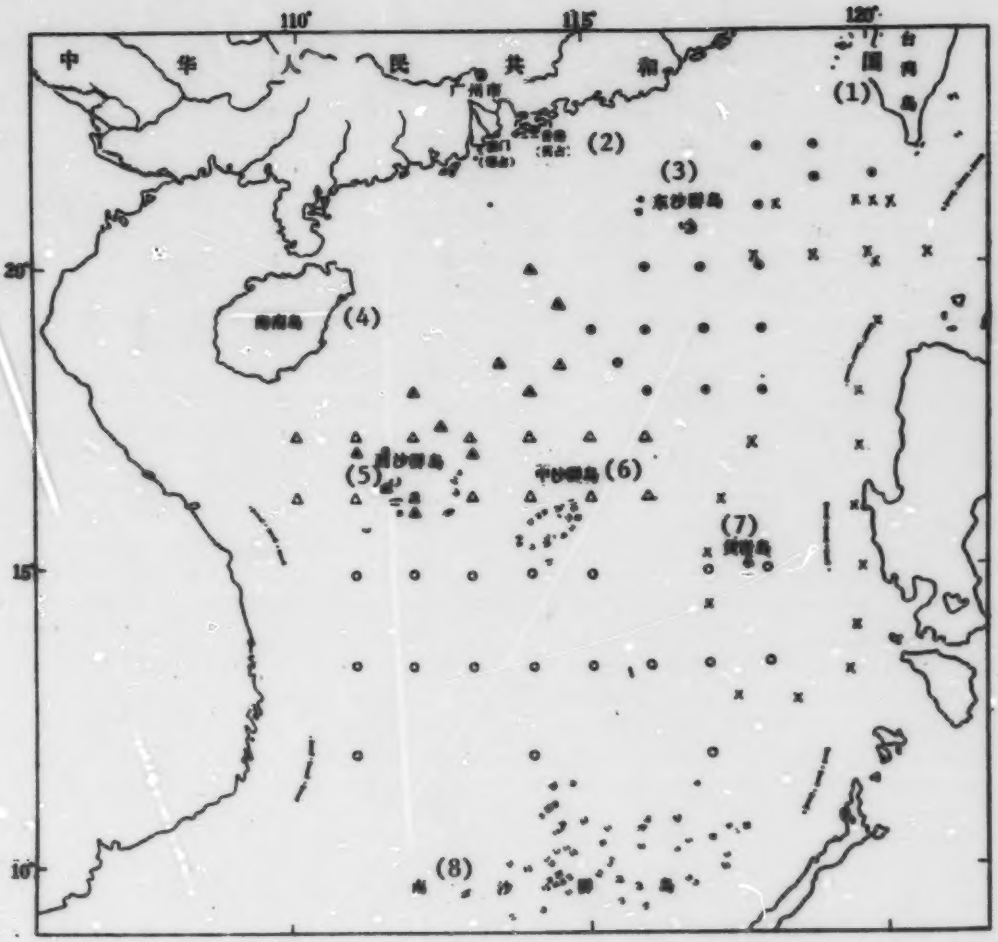
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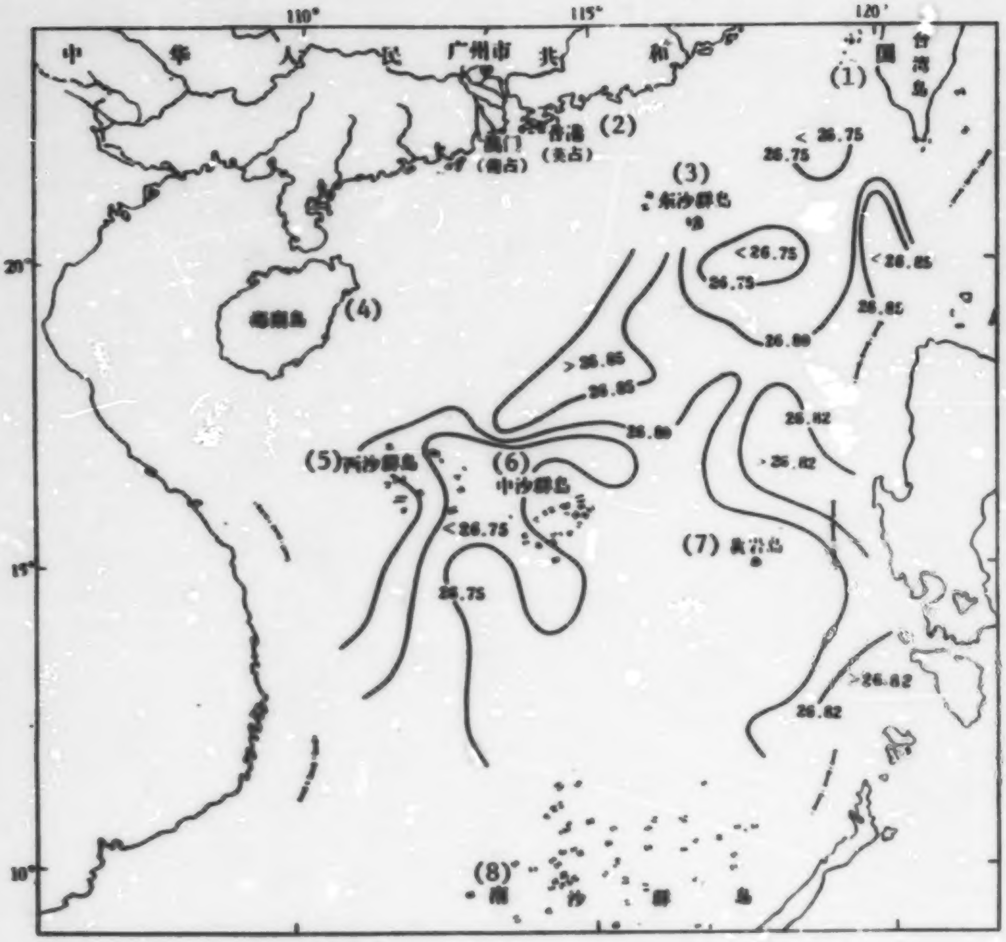
Figure 1. Map of the north central part of the South China Sea showing the sites of the voyages from which data used in this work was obtained.
o "Shi Yan Hao" (June, July 1978); ● "Shi Yan Hao" (June, July 1979); ▲ "Xiang Yang Hong Hao" (July 1976); Δ "Hong Qi #088" (May 1976) and "Jiu Lian Hao" (August 1971)

Key:

1. Taiwan
2. Hong Kong
3. Dongsha Archipelago
4. Hainan Island
5. Xisha Archipelago
6. Zhongsha Archipelago
7. Huangyan Island
8. Nansha Archipelago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(7) 黄岩岛
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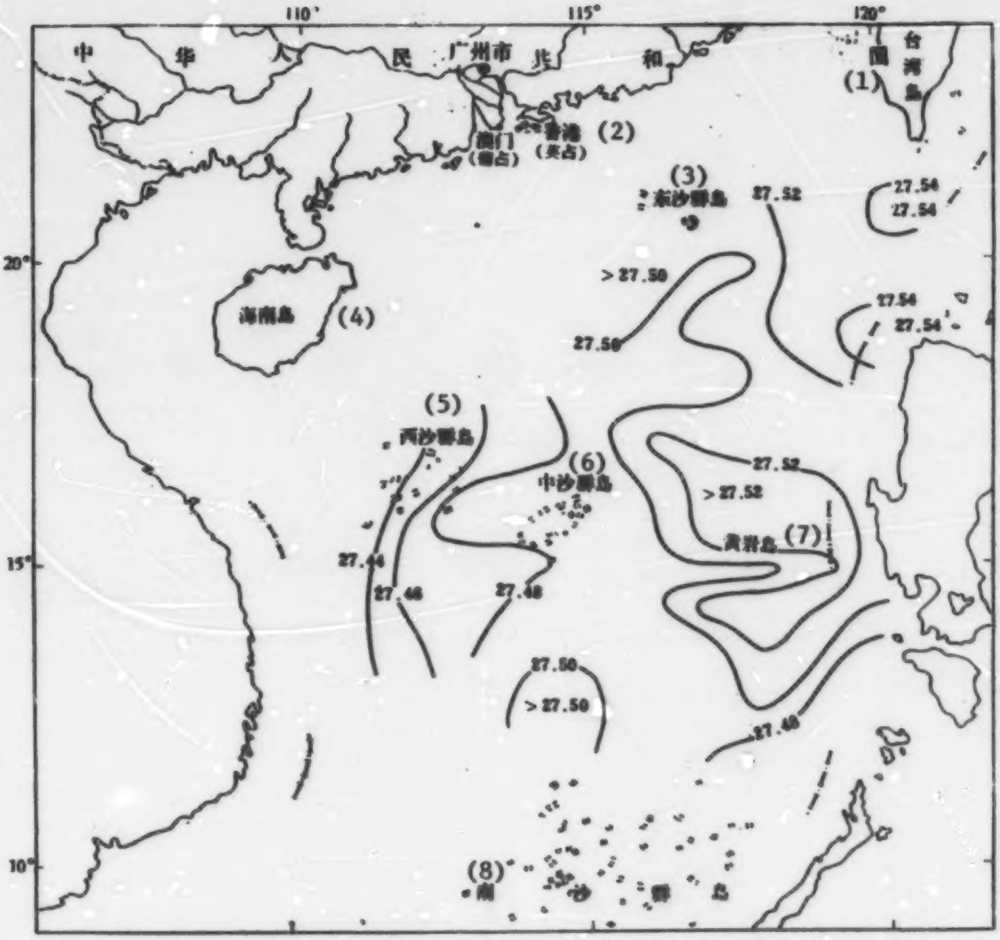
Figure 2. σ_t distribution at the 500 meter layer of the north central South China Sea

Key:
1. Taiwan
2. Hong Kong
3. Dongsha Archipelago
4. Hainan Island
5. Xisha Archipelago
6. Zhongsha Archipelago
7. Huangyan Island
8. Nansha Archipelago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西沙群岛
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中沙群岛
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>27.52
黄岩岛 (7)
27.44
27.48
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>27.50
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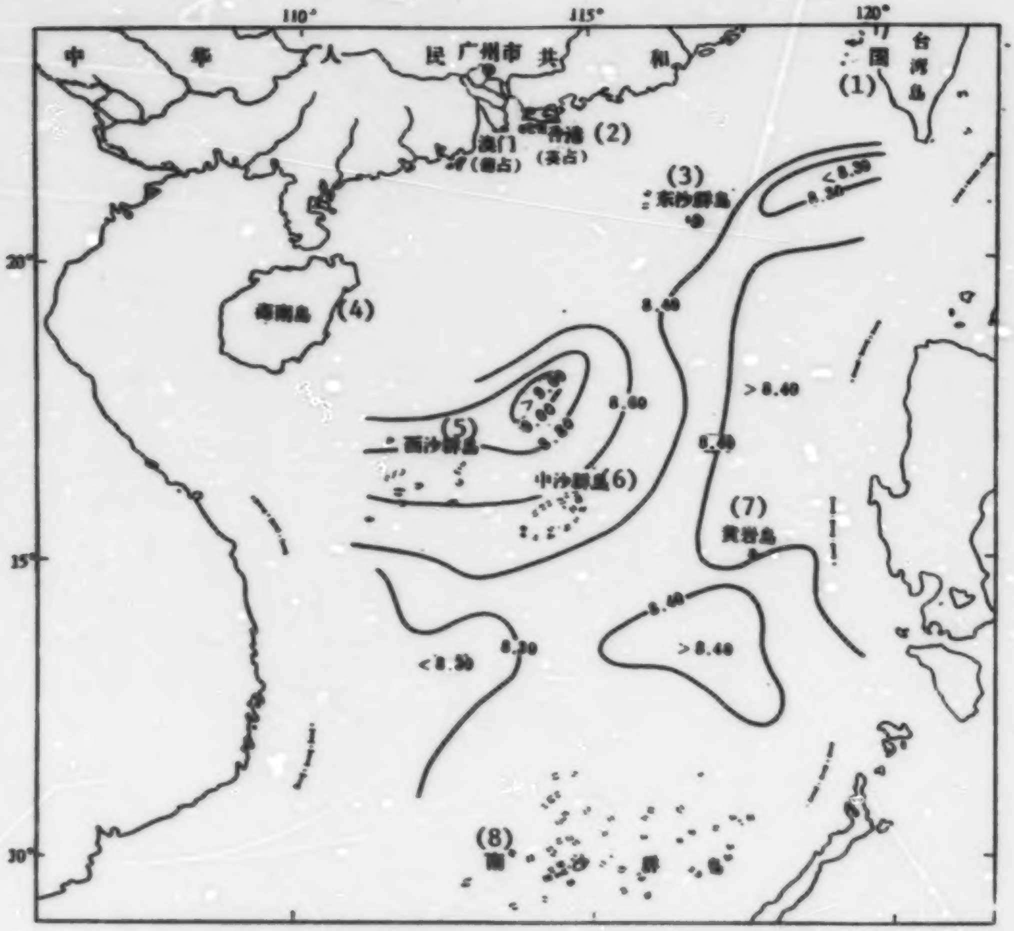
南 沙 群 岛

Figure 3. σ_t distribution at the 1200 meter layer of the north central South China Sea

Key:

1. Taiwan
2. Hong Kong
3. Dongsha Archipelago
4. Hainan Island
5. Xisha Archipelago
6. Zhongsha Archipelago
7. Huangyan Island
8. Nansha Archipelago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> 8.40
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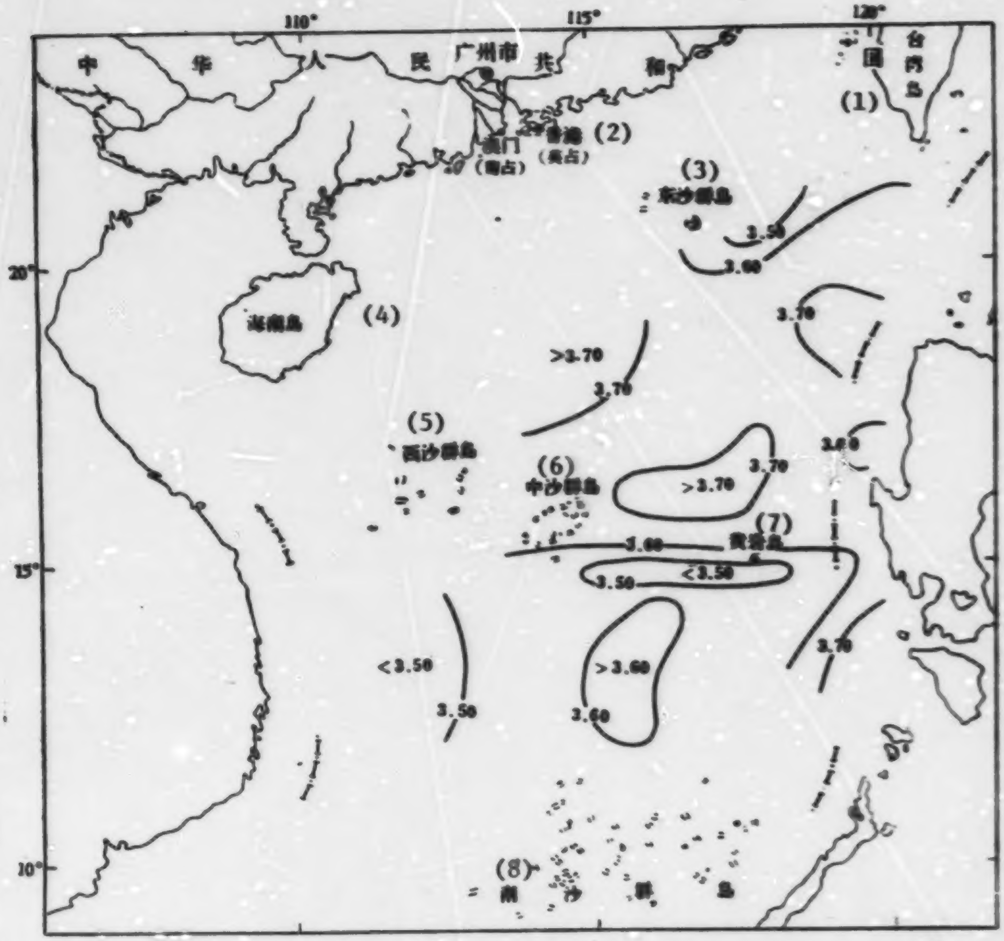
< 8.30
8.40
> 8.40

Figure 4. σ_t 26.79 surface temperature distribition (°C) in the north central South China Sea

Key:

1. Taiwan
2. Hong Kong
3. Dongsha Archipelago
4. Hainan Island
5. Xisha Archipelago
6. Zhongsha Archipelago
7. Huangyan Island
8. Nansha Archipelago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<3.50
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3.70

Figure 5. σ_t 27.50 surface temperature distribution (°C) in the north central South China Sea

Key:

1. Taiwan
2. Hong Kong
3. Dongsha Archipelago
4. Hainan Island
5. Xisha Archipelago
6. Zhongsha Archipelago
7. Huangyan Island
8. Nansha Archipelago

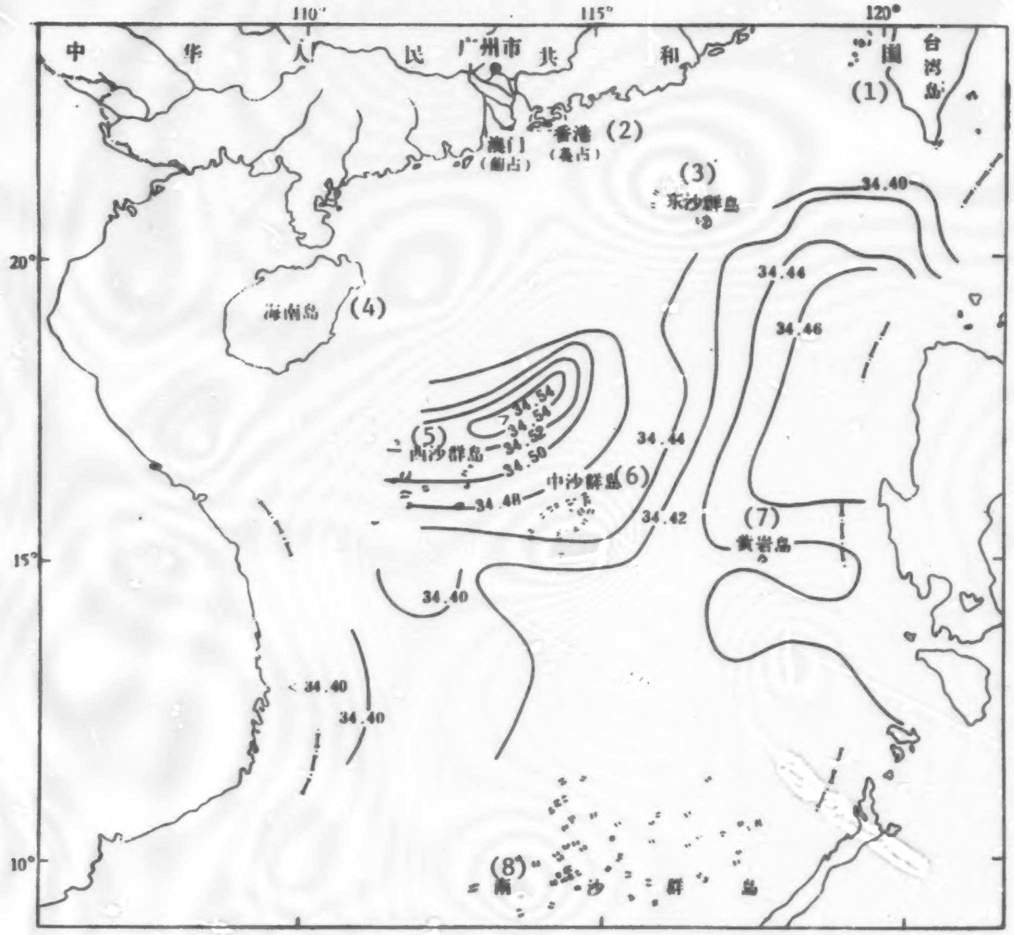
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Figure 6. σ_t salt 26.79 salt content distribution (per thousand) in the north central South China Sea

Key:

1. Taiwan
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3. Dongsha Archipelago
4. Hainan Island
5. Xisha Archipelago
6. Zhongsha Archipelago
7. Huangyan Island
8. Nansha Archipelago

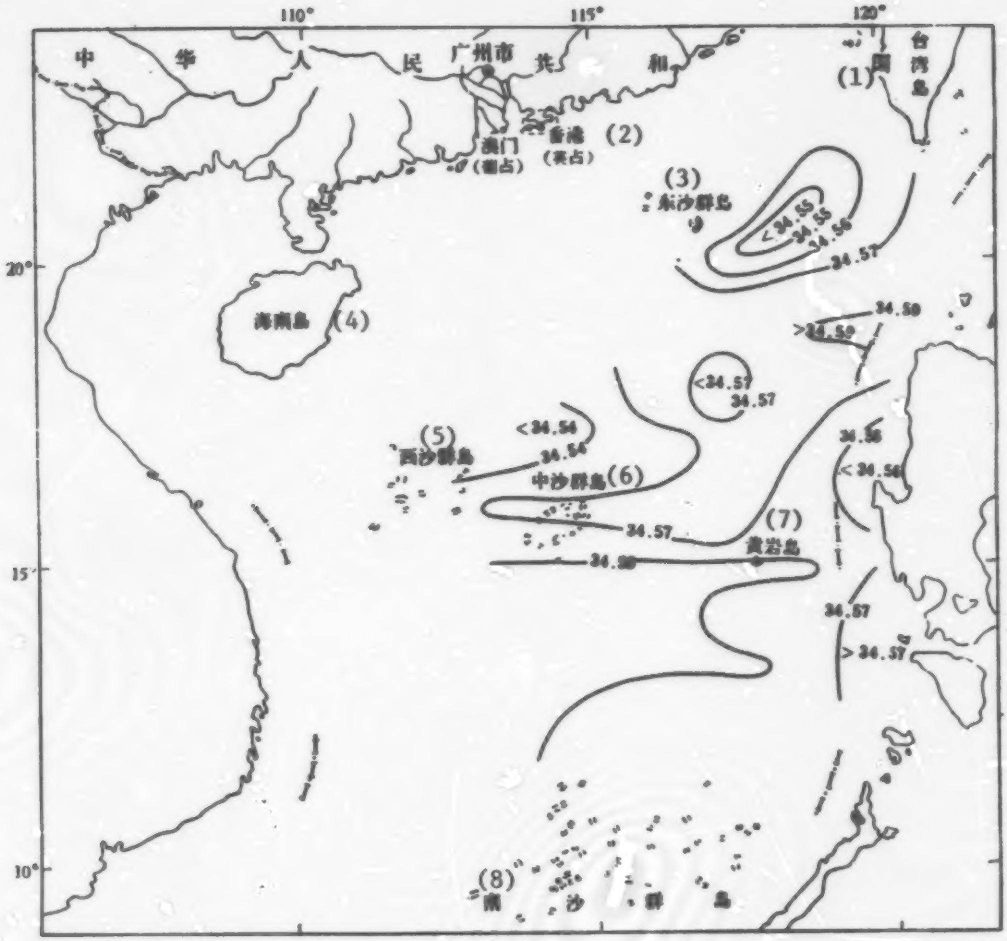
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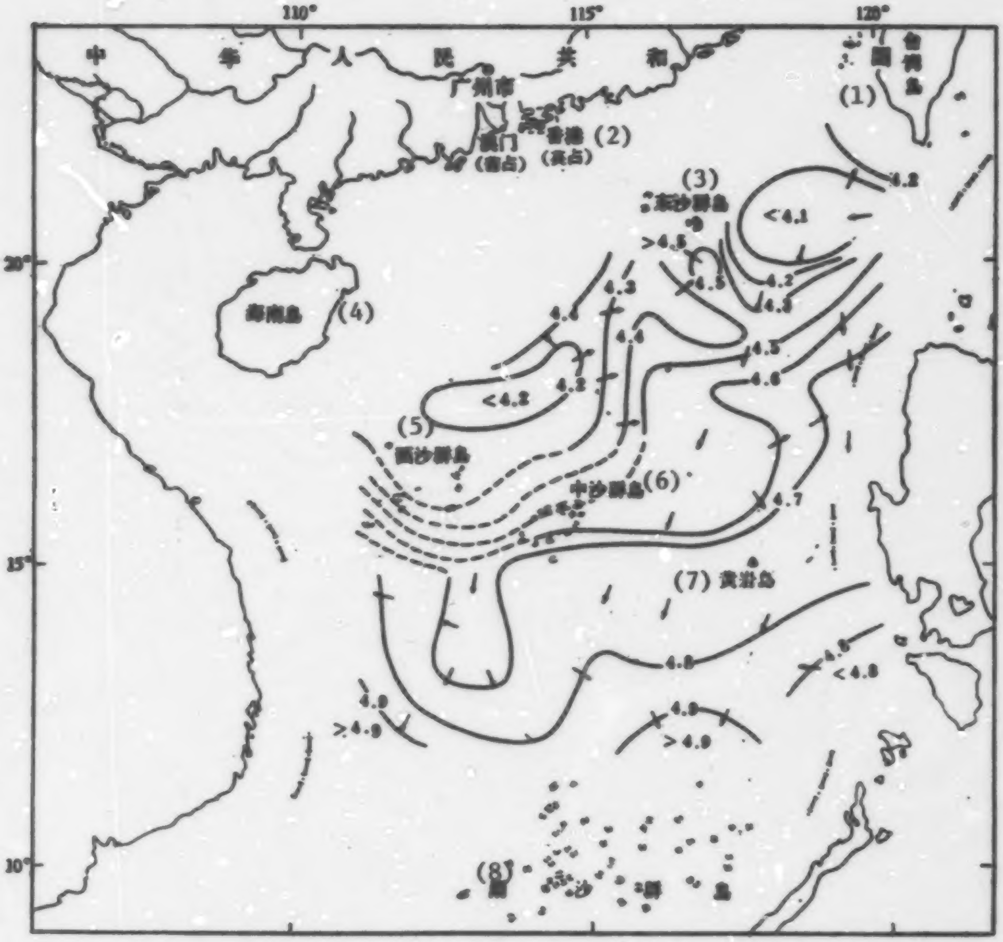
Figure 7. σ_t 27.50 salt content distribution (per thousand) in the north central South China Sea

Key:

1.	Taiwan	5.	Xisha Archipelago
2.	Hong Kong	6.	Zhongsha Archipelago
3.	Dongsha Archipelago	7.	Huangyan Island
4.	Hainan Island	8.	Nansha Archipelago



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>4.9

Figure 8. σ_t 26.79 A.O.U. distribution (ml/l) in north central South China Sea

Key:

1.	Taiwan	5.	Xisha Archipelago
2.	Hong Kong	6.	Zhongsha Archipelago
3.	Dongsha Archipelago	7.	Huangyan Island
4.	Hainan Island	8.	Nansha Archipelago

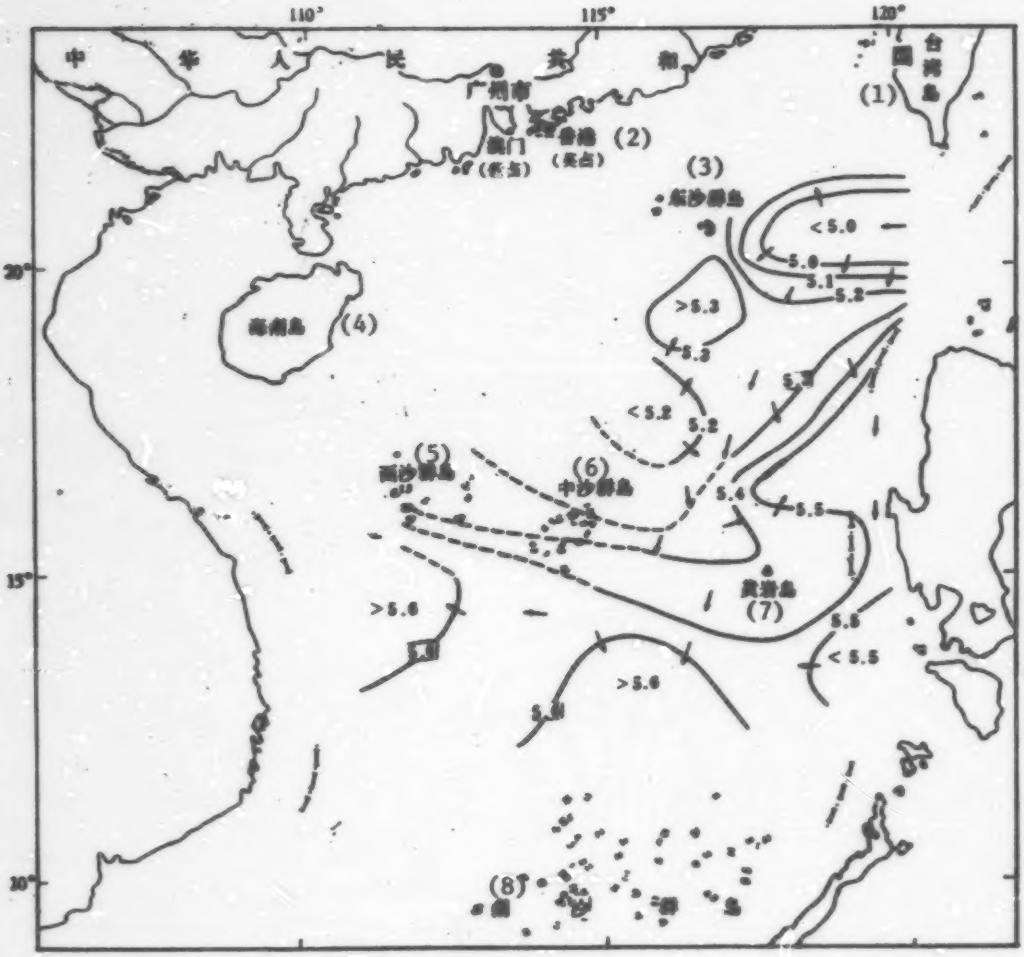
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Figure 9. δ_t 27.50 A.O.U. distribution (ml/l) in north central South China Sea

Key:

1. Taiwan
2. Hong Kong
3. Dongsha Archipelago
4. Hainan Island
5. Xisha Archipelago
6. Zhongsha Archipelago
7. Huangyan Island
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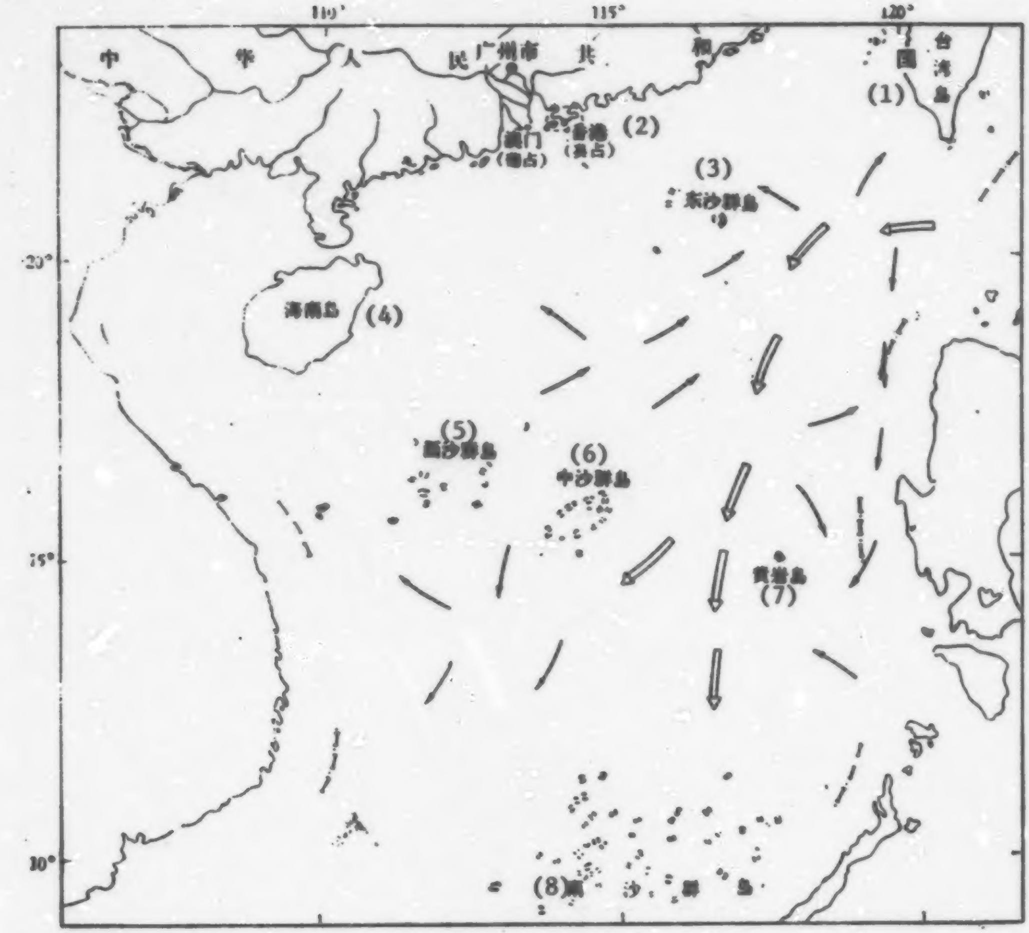
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(8)南沙群岛

Figure 10. δ_t 26.79 circulation diagram in north central South China Sea

Key:

1. Taiwan
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3. Dongsha Archipelago
4. Hainan Island
5. Xisha Archipelago
6. Zhongsha Archipelago
7. Huangyan Island
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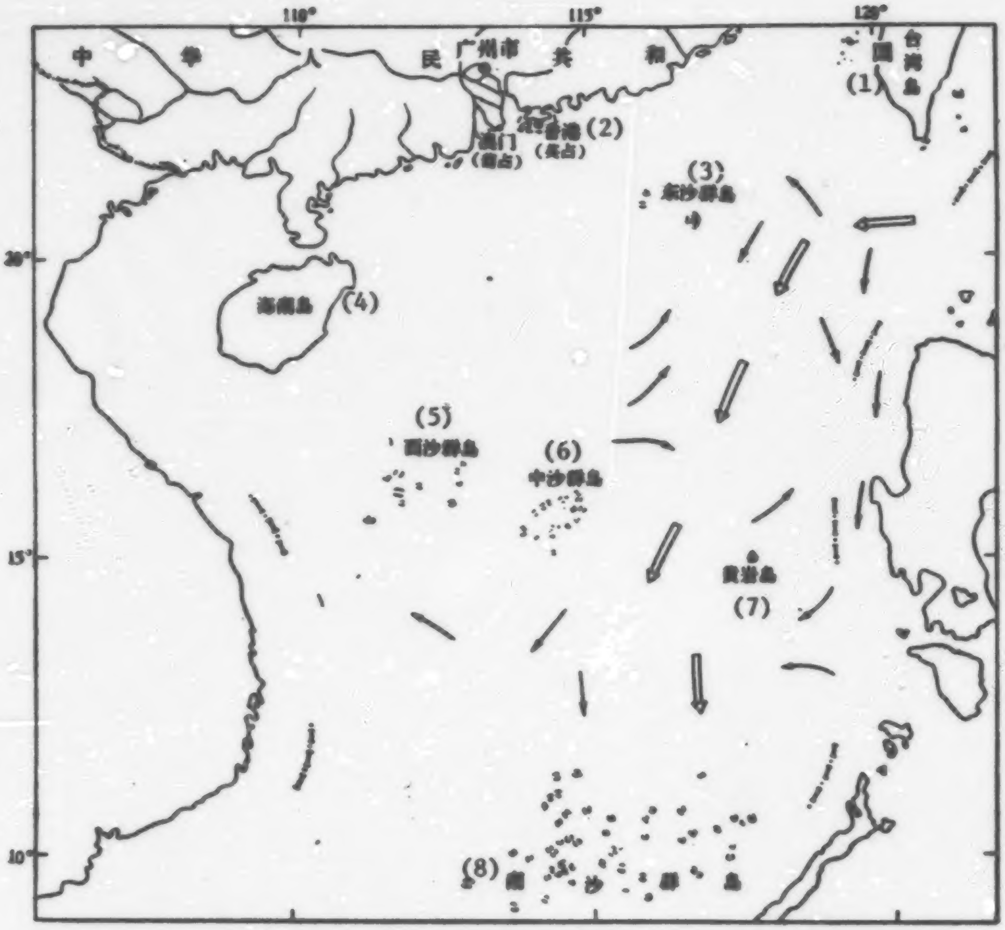

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Figure 11. δ_t circulation diagram in north central South China Sea

Key:

1. Taiwan	5. Xisha Archipelago
2. Hong Kong	6. Zhongsha Archipelago
3. Dongsha Archipelago	7. Huangyan Island
4. Hainan Island	8. Nansha Archipelago

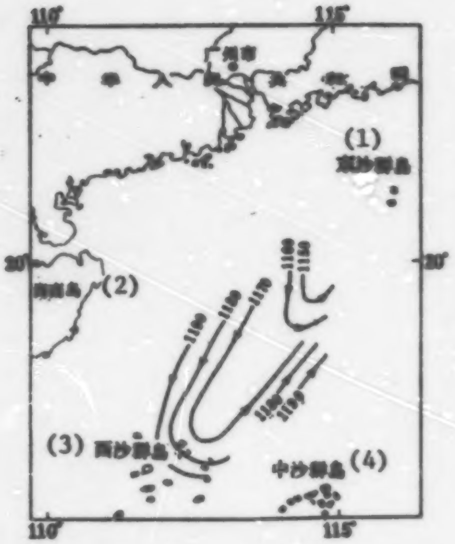
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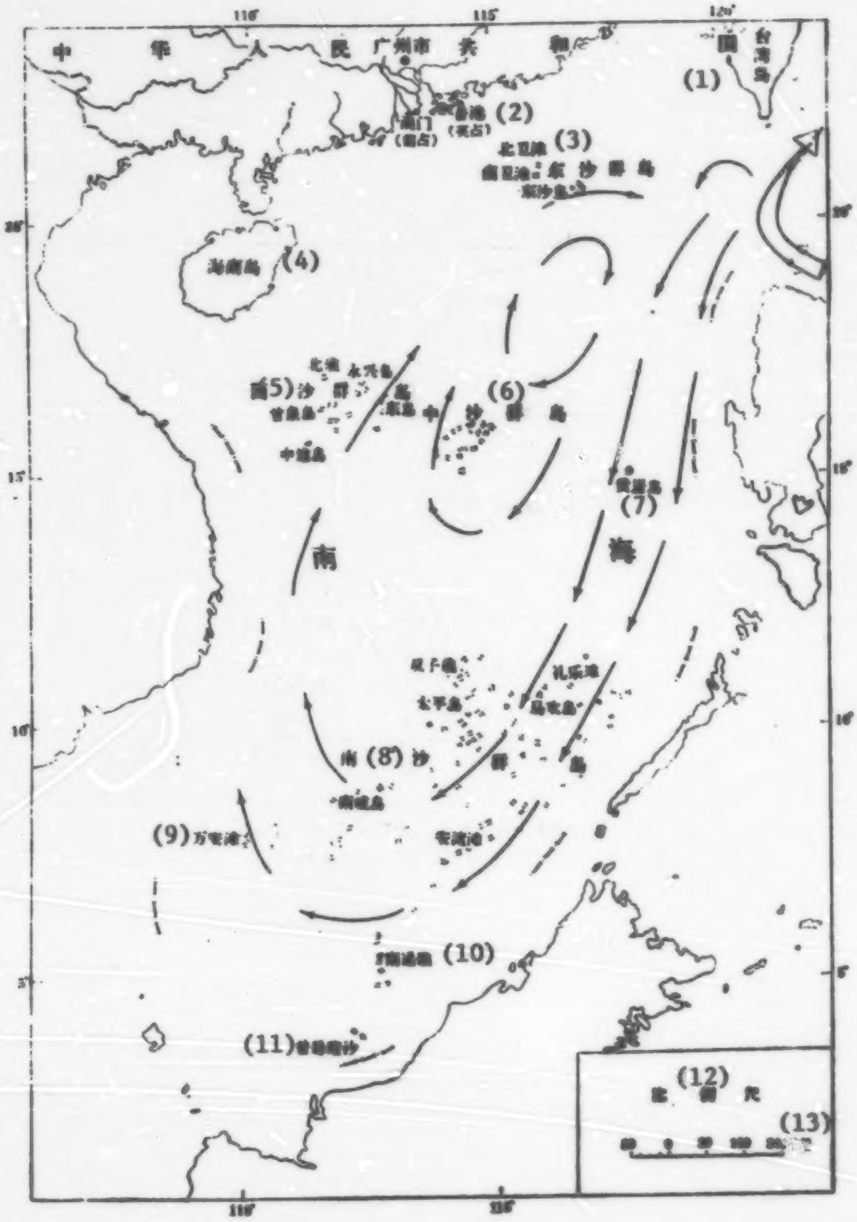
Figure 12. Map of the August 400 meter layer dynamic altitude in north central South China Sea (relative to 700 meters)

Key:
1. Dongsha Archipelago
2. Hainan Island
3. Xisha Archipelago
4. Zhongsha Archipelago



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(13)

Figure 13. Map of the summer pattern of circulation in the middle layer of the South China Sea

Key:

1. Taiwan
2. Hong Kong
3. Dongsha Archipelago
4. Hainan Island
5. Xisha Archipelago
6. Zhongsha Archipelago
7. Huangyan Island
8. Nansha Archipelago
9. Wan'an Shoals
10. Nantong Reef
11. Zengmu Reef
12. Scale
13. Kilometers

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13226/6091
CSO: 4008/1067

SHANGHAI PLANT TURNING OUT VERSATILE ROBOT LINE

Beijing RENMIN RIBAO (OVERSEAS EDITION) in Chinese 22 Aug 86 p 1

[Text] [Photo caption]

A robot capable of grasping, moving, seeing, hearing, and speaking is now in batch production at the Shanghai No. 1 Machine Tool Plant. Capable of controlled body movements, this robot also has a voice synthesizer with 64 phonemes and four tones.

/7358
CSO: 4008/9

NEW-TYPE RAPID OSCILLATION, SELF-MODE-LOCKING PHENOMENON IN HIGH-GAIN LASER

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6, No 7, Jul 86 pp 585-591

[Article by Li Shifang [2621 0013 5364], Hu Qiquan [5170 0120 6898], and Lin Fucheng [2651 4395 2052] of the Shanghai Institute of Optics and Fine Mechanics, the Chinese Academy of Sciences; first paragraph is source supplied abstract]

[Text] Abstract: A new type of rapid oscillations and self-mode-locking phenomenon in a high-gain laser is reported. Its mechanism is due to the spatial modulation of the population inversion, which will in turn cause an intensity modulation in the time domain. The oscillation frequency equals the longitudinal mode internal $c/2\ell$.

I. Introduction

The CuCl vapor laser has a very high gain but its lower energy level is a metastable state and it is therefore a pulsed self-terminating laser. Many of the unique applications of CuCl laser have received wide attention.[1] The high gain also facilitated the investigation of a number of fundamental problems in laser physics.

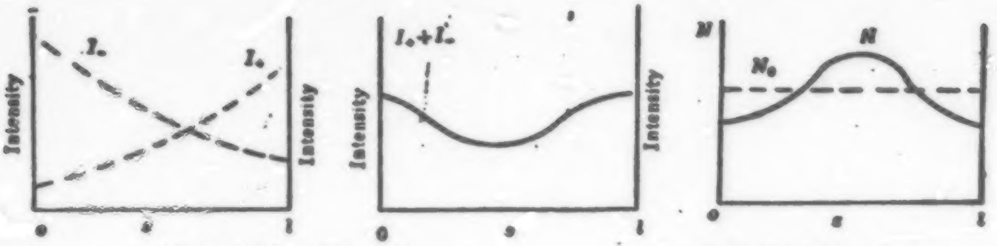
II. Theoretical Analysis

In a low Q cavity the number of particles far exceeds the threshold and two oppositely propagating light fields will produce a distribution like that shown in Figure 1(a) in the medium. In the meantime the interaction of two light fields with the population inversion causes the inverse population to assume a spatial distribution shown in Figure 1(b). The amplification of the light will therefore be space dependent.

Using the setup shown in Figure 2 for a two-level system and letting the oppositely propagating light intensities be $I_{\pm}$, the transport equation becomes

$$(\partial_t \pm c\partial_z) I_{\pm} = c\sigma N I_{\pm}, \tag{1}$$

$$\partial_t N = -2\sigma N (I_+ + I_-) - N/\tau + W. \tag{2}$$



(a) Spatial distribution of laser intensity in gain medium

(b) Spatial distribution of inverse population in gain region

Figure 1

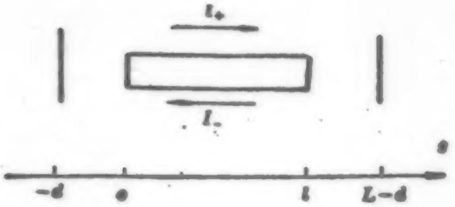


Figure 2. A model of laser used for calculation

Here we use the theory of the rate equation and N is the inverse population, a function of space and time. σ is the cross-section for stimulated emission (ignoring the energy level degeneracy), $1/\tau$ is the relaxation time, and W is a pump term.

For a zeroth order approximation, we assume the inverse population does not depend on space, i.e., $N = N_0(t)$. Substituting this into (1) and (2), we may solve for $I_{0,\pm}$ and N_0. Here $I_{0,\pm}$ are function of space and time but N_0 is only a function of time. The solution for this case is metastable; that is, the rate of change of the light intensity is smaller than the round trip time of light in the cavity.

In the first order approximation, we substitute the solution $I_{0,\pm}$ (z,t) into (2) and N will have a term that is space dependent. If $N = N_0 + \Delta N$, then ΔN is taken to be the fundamental frequency term $-mN_0\cos kz$ of the spatial Fourier series. Here $k = 2\pi/\ell$ and ℓ is the length of the gain medium.

Assume the spatial modulation of N causes a change of $\Delta I_\pm$ in $I_\pm$, then

$$(\partial_t \pm c\partial_z)\ln I_{0,\pm}\left(1+\frac{\Delta I_\pm}{I_{0,\pm}}\right) \simeq (\partial_t \pm c\partial_z)\left[\ln I_0 + \frac{\Delta I_\pm}{I_{0,\pm}}\right] - cN_0\sigma(1-m\cos kz),$$

and

$$(\partial_t \pm c\partial_z)\frac{\Delta I_\pm}{I_{0,\pm}} = -c\sigma N_0 m\cos kz,$$

Let $$x = t + z/c, \quad y = t - z/c$$

then

$$\partial_x \frac{\Delta I_+}{I_{0,+}} = -c\sigma N_0 n \cos\left[\frac{1}{2} k(x-y)\cdot c\right], \tag{3}$$

$$\partial_y \frac{\Delta I_-}{I_{0,-}} = -c\sigma N_0 n \cos\left[\frac{1}{2} k(x-y)\cdot c\right]. \tag{4}$$

In solving this set of equations we assume the changes in N_0 and n within one period of ΔI are small. (It will be shown below that for a period of 1 ns or so, the change in I is less than 10 percent.) So,

$$\Delta I_+ = -\frac{l}{\pi}\sigma N_0 n I_{0,+}\left[\sin kz + \sin\frac{1}{2} kc(t - z/c) + c_+(t - z/c)\right], \tag{5}$$

$$\Delta I_- = -\frac{l}{\pi}\sigma N_0 n I_{0,-}\left[\sin kz + \sin\frac{1}{2} kc(t + z/c) + c_-(t + z/c)\right], \tag{6}$$

where c_+ and c_- are functions to be determined.

(1) If there is no feedback, then (5) and (6) lead to

$$I_{0,+}(0, t) - \Delta I_+(0, t) = 0; \quad I_{0,-}(l, t) - \Delta I_-(l, t) = 0,$$

and hence

$$c_+(y) = -\sin\frac{1}{2} kcy, \quad c_-(x) = -\sin\frac{1}{2} kcx,$$

and the output $\Delta I_+ = \Delta I_- = 0$. There will be no oscillations in this case.

(2) If there is a feedback system, ΔI_+ and ΔI_- may be found from boundary conditions.

If the left mirror has a reflectivity r_1 and the right mirror has r_2, then (detailed derivations are given in the Appendix):

$$c_+(y) = a_+\cos\frac{1}{2} kcy + b_+\sin\frac{1}{2} kcy,$$

$$c_-(x) = a_-\cos\frac{1}{2} kcx + b_-\sin\frac{1}{2} kcx,$$

where

$$a_+ = R_2 a_-; \; b_+ = R_1(1 + b_-) - 1;$$
$$(R_1 \sin\varphi)a_- + (R_1\cos\varphi - R_2)b_- = R_2 - R_1\cos\varphi,$$
$$(R_1\cos\varphi)a_- - (R_1\sin\varphi)b_- = R_2\sin\varphi;$$

Here $\varphi=k(L-l)$, L is the cavity length, and R_1 and R_2 are given in the Appendix. From the equations above, it is easy to show that

$$a_-=\frac{2R_1\sin\varphi(R_2-R_1\cos\varphi)}{R_1^2+R_2^2-2R_1R_2\cos\varphi},$$
$$b_-=\frac{(R_1^2\cos2\phi-2R_1R_2\cos\varphi t R_2^2)}{(R_1^2+R_2^2-2R_1R_2\cos\varphi)}. \qquad (7)$$

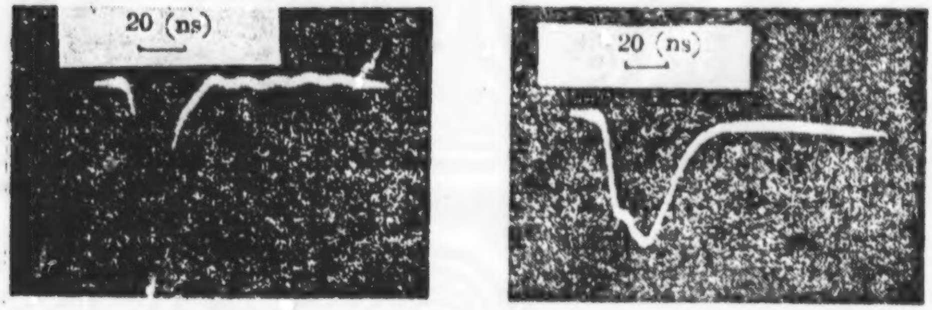
The oscillation frequency of $\Delta I_\pm$ is equal to 1/2 kc. Since $k=\frac{2\pi}{l}$, the oscillation frequency is

$$\nu=\frac{1}{2\pi}\cdot\frac{1}{2}kc=\frac{c}{2l}.$$

III. Experimental Verification

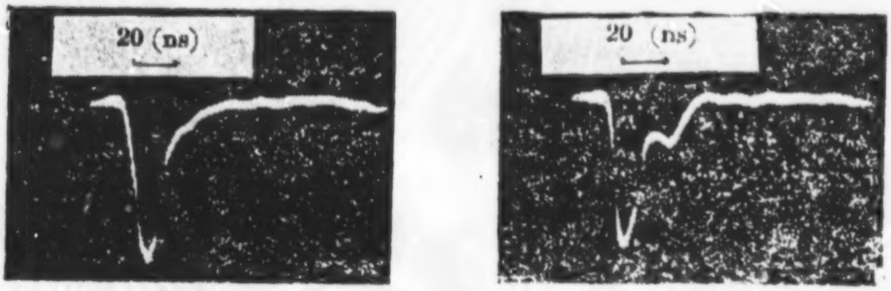
The experiment makes use of a CuCl laser[2] developed by the Shanghai Institute of Optics and Fine Mechanics. The discharge zone is 50 cm long. Figure 3(a) shows the oscilloscope trace (amplified spontaneous radiation) of the 510.6 nm and 578.2 nm fluorescence. Figure 3(b) shows the waveform of the 578.2 nm laser output with a total reflection mirror at one end of the cavity and a flat glass plate on the other end. Based on $\ell = 50$ cm the theoretically expected oscillation frequency caused by the inhomogeneith is $\nu = c/2\ell = 300$ MHz. We measure the oscillation frequency from the oscilloscope photos. The average value is 300 MHz and the statistical mean square deviation is $\sigma = 8.9$ MHz. The agreement is therefore good.

Equation (7) also shows that, when $\phi = 2\pi n$, the modulation amplitude produced by the feedback is in phase and enhanced. For example, a_ and b_ become indefinite when $R_1 = R_2$. Equation (A-8) in the Appendix shows that $R_1 - R_2$ is infinitesimal, but a_ becomes infinity when $\phi = 2\pi n$. The system then deviates far from the zeroth order approximate solution and shows self-mode-locking. Figures 4(a) and 4(b) show the 578.2 nm output laser waveform for a 120 cm long cavity with flat glass plates at the two ends. The self-mode-locking effect is quite evident and the mode-locking can sometimes reach 100 percent, as in Figure 4(b). Such instability may cause only one pulse to exist in the cavity and only one output pulse. Figure 5 shows a single laser pulse whose pulse width is limited by the equipment resolution of 1 ns. This type of self-mode-locking phenomenon is different from the "passive mode-locking" due to the absorption of unexcited atoms as reported in Ref. 3. The self-mode-locking is caused by the spatial inhomogeneity of the inverse population that results from the interaction between the excited atoms and the light field. Experimentally the self-mode-locking phenomenon is only observable in certain cavities when the cavity length and the gain length satisfy a certain relationship (generally $R_1 \approx R_2$ and $L = n\cdot\ell$, $n = 2,3,\ldots$) and when the reflectivity of the mirror is low (such as 8 percent reflectivity of a glass plate). The measured repetition frequenc, of the mode-locked sequential pulses is 109 MHz and the ratio of the repetition frequency to the oscillation is $2.93 \approx 3$, in agreement with the theory.



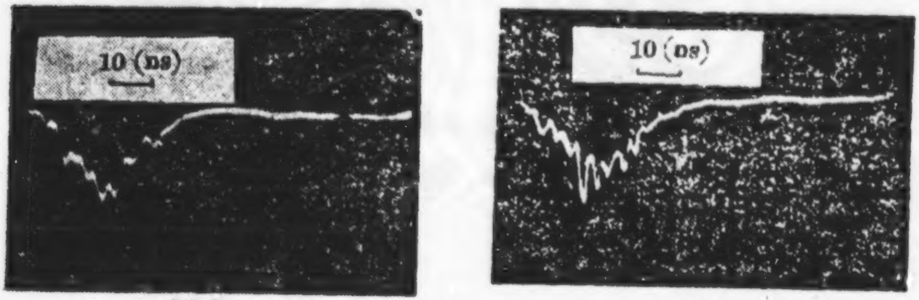
510.6 nm 578.2 nm

(*a*) Time evolution of amplified spontaneous emission from the discharge tube



510.6 nm 578.2 nm

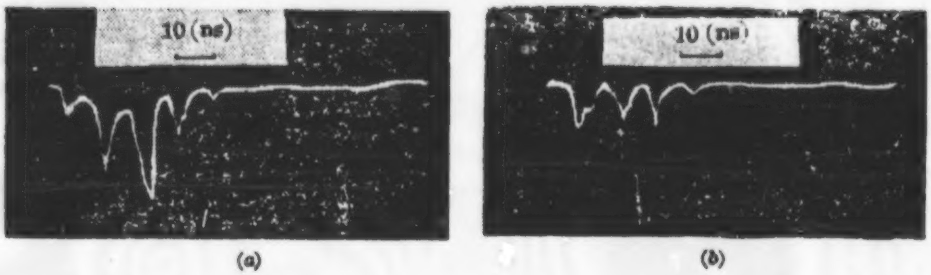
(*b*) Time evolution of laser with a total reflection mirror and a glass plate as reflectors



510.6 nm 578.2 nm

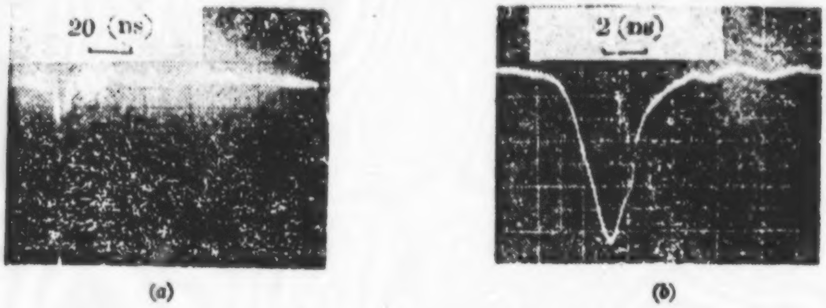
(*c*) Time evolution of the laser with two glass plates as reflectors

Figure 3



(a) (b)

Figure 4. Waveforms of 578.2 nm self-mode-locked laser output with two glass plates as reflectors and a prism inserted in the cavity



(a) (b)

Figure 5. Single pulse laser output obtained under the same conditions as in Figure 4. The time scale in (b) is limited by the measuring equipment. (Time scales in (a) and (b) are 10 ns/div and 1 ns/div respectively)

IV. Conclusion

We reported the observation and analysis of a new type of rapid oscillations in high gain lasers caused by the spatial inhomogeneity of the population inversion. This type of oscillation is different from the relaxation oscillation^4 caused by the instability of the coupling equation solution in the interaction of the inverse population and the light field. The conditions for observing the new rapid oscillations require a large spatial modulation of the inverse population. The following conditions must be met:

(1) The Q of the cavity cannot be too great; otherwise the inverse population remains near the threshold and the modulation will be small.

(2) The Q of the cavity cannot be too small; otherwise the intensity will be too low and the population inversion will not be saturated enough for modulation. The light intensity in the cavity cannot be too high either; otherwise the inverse population will be high saturated and $I_+ \approx I_{0,+}z$, $I_- \approx I_{0,-}(1-z)$, $I_+ + I_- \approx$ constant, consequently the spatial modulation is lost.

(3) From Eqs. (1) and (2), the gain medium in the cavity must have a very high gain.

In addition, the cavity length L and the reflectivity r of the cavity mirror must satisfy a certain relationship so that a_+, a_-, b_+, and b_- determined by (7) have certain values. When any of them becomes infinity the system will deviate far from the zeroth order approximate solution and makes a transition to the self-mode-locked state.

The authors thank Zhang Guiyan [1728 2710 3601] and Jing Chunyang [2529 2504 7123] for providing the CuCl laser.

Appendix

We write the boundary conditions as

$$\Delta I_+(t,\ 0)=r_1\Delta I_-(t,\ 0), \tag{A-1}$$

$$\Delta I_-(t,\ l)=r_2\Delta I_+\left(t-2\frac{L-l}{c},\ l\right). \tag{A-2}$$

and let

$$e_+(y)=a_+\cos\frac{1}{2}kcy+b_+\sin\frac{1}{2}kcy,$$

$$e_-(x)=a_-\cos\frac{1}{2}kcx+b_-\sin\frac{1}{2}kcx. \tag{A-3}$$

We then substitute (A-3) into (A-1) and set the coefficients of cos ½kct and sin ½kct on the two sides of the equation equal. We obtain

$$a_+=R_1a_-;\ b_+=R_1(1+b_-)-1;\ R_1=r_1\frac{I_{0,-}(0)}{I_{0,+}(0)}, \tag{A-4}$$

Substituting (A-3) into (A-2) and using ½kℓ = π, we have

$$R_2\left[\sin\left(\frac{1}{2}kct\right)+a_-\cos\left(\frac{1}{2}kct\right)+b_-\sin\left(\frac{1}{2}kct\right)\right]=\sin\left(\frac{1}{2}kct-\phi\right)$$

$$+a_+\cos\left(\frac{1}{2}kct-\phi\right)+b_+\sin\left(\frac{1}{2}kct-\phi\right) \tag{A-5}$$

where

$$\phi=k(L-l),\quad R_2=\frac{I_{0,-}(l)m\left(t-2\frac{L-l}{c}\right)}{r_2I_{0,+}(l)m(t)}. \tag{A-6}$$

We expand the right-hand side of (A-5) and compare the coefficients of sin ½kct and cos ½kct on the two sides. With the help of (A-4), we obtain

$$(R_1\sin\phi)a_-+(R_1\cos\phi-R_2)b_-=R_2-R_1\cos\phi,$$

$$(R_1\cos\phi-R_2)a_--(R_1\sin\phi)b_-=R_1\sin\phi. \tag{A-7}$$

APPLIED SCIENCES

UV EXCIMER LASER USED IN TRIGGERING LOW-JITTER SPARK GAPS THROUGH FIBER

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6, No 7, Jul 86 pp 625-629

[Article by Lou Qihong [2869 4388 3163], Qi Jianping [4359 1696 1627], Ding Zean [0002 3419 1344], Huo Yunsheng [7208 5366 3932], and Wang Runwen [3769 3387 2429] of the Shanghai Institute of Optics and Fine Mechanics, the Chinese Academy of Sciences; first paragraph is source supplied abstract]

[Text] Abstract: The transmission characteristics of the radiation from a UV XeCl excimer laser through fused quartz fibers have been investigated. The laser beam transmitted via optical fiber was used to trigger a spark gap. Experimental results show that the triggering jitter is less than 3 ns. With use of two fibers, the same laser was used to trigger two spark gaps synchronously.

I. Introduction

The pumping source or the preionization source of high power pulsed gas discharge lasers usually consist of a multistage Max generator or transmission lines. The voltage pulse must have a fast rise time and low jitter. This means that the pulsed voltage source must have a spark gap with very low jitter. In high voltage discharge the pulse is usually used to trigger the spark gap switch, the jitter time of the spark gap depends strongly on the risetime of the signal.[1] However, a fast risetime requires additional spark gap or other components and the system becomes complicated. Moreover, electrically triggered high voltage systems are also susceptible to the interference of other electrical signals and may have instabilities in their trigger state.

A strong laser beam may be used to trigger the spark gap.[2] Since it is free from the interference of high voltage discharge pulses and has a low jitter time, it has been used in the technology of high pressure plasma, accelerators, and lasers. In the early studies visible and infrared lasers were used. The laser is collimated and focused at the spark gap. The requirement of precise alignment has limited its usefulness. Ultraviolet lasers should have better ionization and trigger characteristics than visible or infrared lasers. Fiber optics transmission allows us to introduce the high power laser beam directly into the spark gap, and the optical system in the atmosphere and the requirement for precise alignment are eliminated. By adjusting the length of the fiber optics, the trigger delay time is controlled. The same laser beam may go through several fibers for the synchronous triggering of several switches or the trigger of several channels in the same switch. The technique is therefore very useful in practical applications.

II. Transmission Characteristics of XeCl Excimer Laser Light in Quartz Fiber

The experimental setup for measuring the transmission characteristics of XeCl excimer laser light in quartz fiber is shown in Figure 1. For a XeCl laser pumped by an X-ray preionization pulsed discharge, the typical pulse width is about 70 ns (FWHM) and the output energy is about 0.1-1 J.

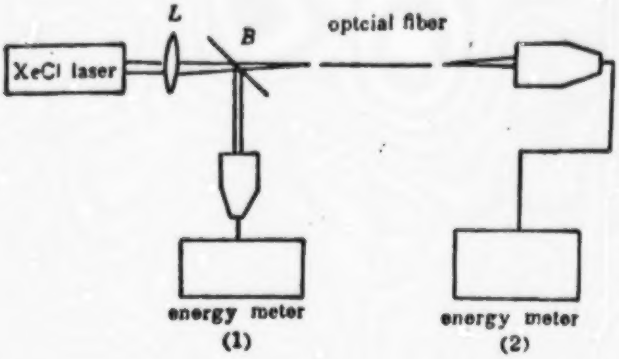


Figure 1. Schematic of the experimental setup for measuring the XeCl laser transmission characteristics through an optical fiber

The laser beam is coupled into the optical fiber by lens L. By changing the distance between the lens and the fiber surface and the laser output energy, the input power density of the fiber may be controlled. The beam splitter B, an uncoated quartz plate, is used to monitor the incident laser energy. The energy entering the fiber may be computed knowing the laser spot size at the end surface of the fiber and the cross-sectional area ratio of the incident end of the fiber. To improve accuracy, the spot size of the laser on the incident surface of the fiber is measured with a diaphragm and the average of 10 measurements is taken.

The optical fiber is a model GY-1 low-loss cylindrical quartz fiber. The core diameter is 650 μm, the diameter of the silicon gel coating is 1 mm, the input and output end faces are cut flat and treated at a high temperature. The output of the XeCl laser is multi-mode, the fiber is also multimode, and the coupling between the laser beam and the fiber does not depend on the laser beam quality.

Figure 2 shows the relationship between the input intensity and the output intensity. The length of the fiber is 9.6 m. The reason that we use a long fiber is to facilitate future applications where the laser is at a large

The determinant of the equation is

$$\Delta = R_1^2 - 2R_1R_2\cos\phi = (R_1 - R_2)^2 + 4R_1R_2\sin^2\frac{\phi}{2}.$$

In order for Δ to be zero, we have to satisfy $R_1 = R_2$ and $\sin^2(\phi/2) = 0$ simultaneously. The latter is equivalent to $\cos\phi = 1$. The behavior of a_- and b_- may then be obtained from Eq. (7) in the test under the limits $R_1 - R_2 \to 0$ and $\sin(\phi/2) \to 0$.

For example, (7) gives

$$a_- = \frac{4R_1\cos\frac{\phi}{2}[(R_2 - R_1\cos\phi)/(R_1 - R_2)]}{\left[\frac{R_1 - R_2}{\sin\phi/2} + 4R_1R_2\sin\frac{\phi}{2}\Big/(R_1 - R_2)\right]}. \quad \text{(A-8)}$$

and $a_- \to \infty$ if $(\sin\phi/2)/(R_1 - R_2) \to 0$, when $R_1 - R_2 \to 0$, $\sin\phi/2 \to 0$.

It should be pointed out that, for simplicity, the boundary conditions written above correspond to a special case. The more general boundary conditions satisfying Figure 2 are

$$\Delta I_+(t, 0) = r_1\Delta I_-\left(t - \frac{2d}{c}, 0\right),$$

$$\Delta I_-(t, l) = r_2\Delta I_-\left(t - \frac{2L - 2l - 4d}{c}, l\right).$$

The definitions of R_1 and R_2 then become

$$R_1 = r_1\frac{I_{0,-}(0)m\left(t - \frac{2d}{c}\right)}{I_{0,+}(0)m(t)}, \quad R_2 = \frac{I_{0,-}(l)m\left(t - \frac{2L - 2l - 4d}{c}\right)}{r_2I_{0,+}(l)m(t)}.$$

Then, using the boundary conditions of the zeroth order approximation solution, we have $r_1\frac{I_{0,-}(0)}{I_{0,+}(0)} = 1$, $I_{0,-}(l)/[r_2I_{0,+}(l)] = 1$. As a result, we obtain

$$R_1 = \frac{m(t - 2d/c)}{m(t)}, \quad R_2 = m[t - (2L - 2l - 4d)/c]/m(t).$$

where m depends on the population saturation caused by the light intensity.

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CSO: 4008/94

distance from the spark gap and one laser may be used to trigger two spark gaps separated by a large distance. The attenuation of the laser in the fiber is mainly due to Rayleigh scattering and Raman scattering. At a high pump level, Rayleigh scattering is generally believed to be the main cause for attenuation.

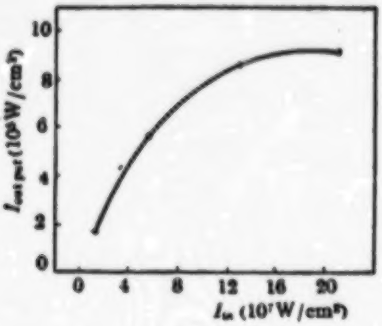


Figure 2. Input intensity of XeCl laser versus output intensity. The optical fiber is 9.6 m long.

According to the analysis of D.A. Pinnow et al., the light scattering coefficient may be written as[3,4]

$$\alpha = \frac{8}{3}\frac{\pi^3}{\lambda^4}(n^8p^2)(kT)\beta_T,$$

where λ is the wavelength, n is the refractive index of the fiber, p is the photoelastic coefficient, k is Boltzmann's constant, T is the absolute temperature, and β_T is the adiabatic compression coefficient. At a wavelength of 308 nm, we estimate $\alpha \sim 0.09$ dB/m. Using Figure 2, the fiber loss is 0.2 dB/m at an incident power density of 20-40 MW/cm^2. At an incident power of 200 W/cm^2, the loss is 0.25 dB/m. The experimental value differs from the prediction of the Rayleigh scattering theory because of the Raman scattering contribution and the presence of impurities in the fiber material.

To compute the power density, we must also measure the laser pulse width and the variation of the pulse width after passing through the fiber. Figure 3 shows the fiber output laser pulse width as a function of the fiber length. The output pulse width is 28 percent greater than the input pulse width. Figures 4(a) and 4(b) show respectively the typical waveform of a XeCl laser pulse and the pulse shape after passing through 9.6 m of fiber. In order to have the receiver operating in the linear region, attenuation plates of various transmissivity are used and the relative values are therefore not proportional.

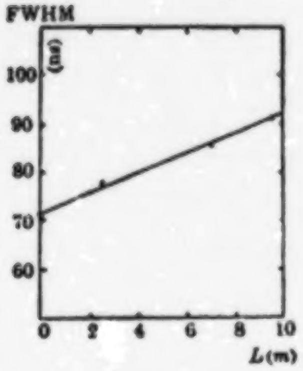
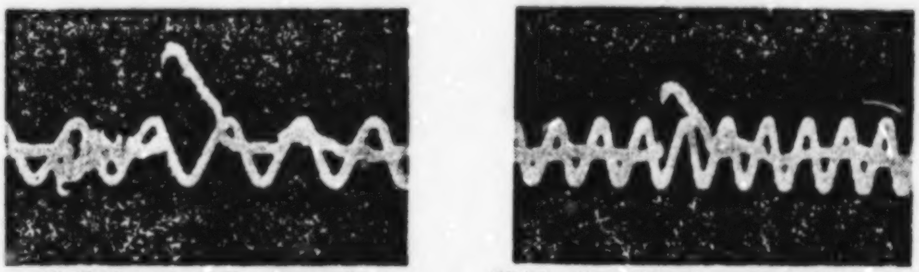


Figure 3. FWHM of the laser pulse output from the optical fiber as a function of the fiber length



(a) XeCl laser output pulse waveform

(b) Waveform of the laser output pulse from the 9.6m long optical fiber

(Time scale is 10MHz)

Figure 4

III. Triggering of the Spark Gap

The experimental setup is shown in Figure 5. The single gap characteristics are measured before the simultaneous triggering of two spark gaps. The gap consists of two ball-shaped electrodes, one has a small hole through the center to accommodate the optical fiber and the gap distance is about 5 mm. The value of the capacitance C is 8.1 nF, the load resistors are in the 10-35 Ω range. The spark signal waveform is detected by the R_3 and R_4 voltage divider and the OK-19 high voltage oscilloscope. The length of the optical fiber is 2.5-7 m. The incident laser waveform is monitored with a receiving system consisting of an ultraviolet photoelectric diode and a fast oscilloscope. By simultaneously measuring the waveform on the load resistor R_1, the delay characteristics and jitter can be obtained. Here we define the delay time as the time interval between the two corresponding starting points on the voltage across the load resistor and on the laser waveform incident on the optical fiber.

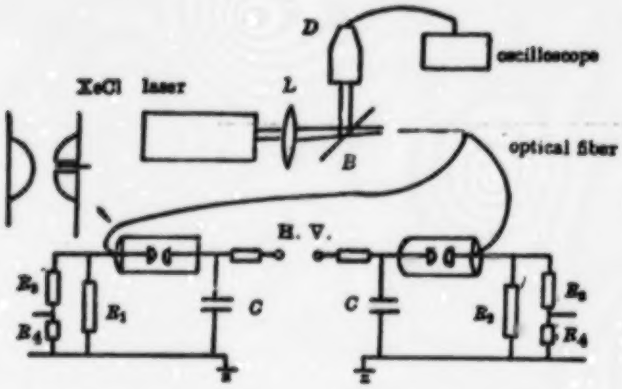


Figure 5. Schematic of the experimental setup for triggering the spark-gap switch by a XeCl laser through optical fiber

The delay time T_D changes with the incident laser power density. Figure 6 shows that T_D is approximately 700 ns when the incident laser power density is low (50 MW/cm^2). As the incident power density reaches 100 MW/cm^2, T_D decreases to about 100 ns. At this time the charging voltage of the gap is about 70 percent of the breakdown voltage. When the gap voltage reaches 90 percent of the breakdown voltage, the delay time T_D drops to about 20 ns. We have also compared spark gaps triggered by a high voltage pulse using a trigger pulse with a 400 kV/μs leading edge. When the gap voltage reaches 70 percent of the breakdown voltage, the delay time is about 460 ns. At 90 percent of the breakdown voltage, T_D is about 100 ns. Therefore, under our testing conditions, the delay time is reduced by a factor of 4-5 when a laser is used for the triggering.

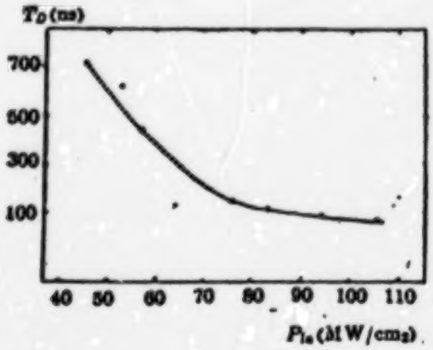
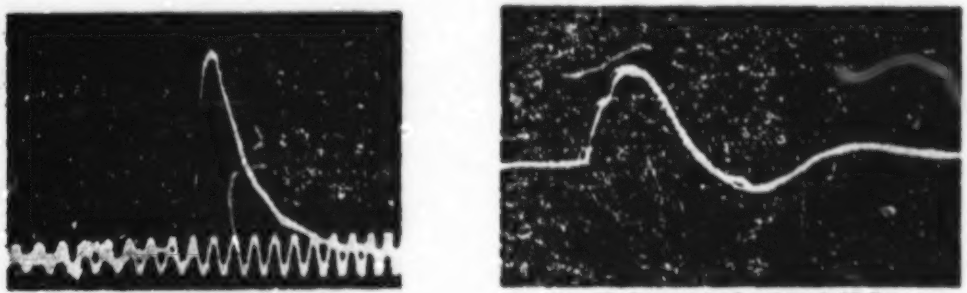


Figure 6. Input intensity of XeCl laser versus delay time T_D

The average delay time $\overline{T}_d$ of the pulses is obtained by making multiple exposures on the same film of the laser triggered spark voltage waveforms on resistor R_1 using the threshold of rise of the laser pulse waveform as the zero of time. The actual delay time of the ith pulse is T_{di}. The jitter of the ith pulse is defined as $\Delta_i = T_{di} - \bar{T}_d$. The root mean square jitter time $\bar{\Delta}_i$ is given by

$$\bar{\Delta}_i = \left[\frac{1}{N}\sum_{i=1}^{N}(\Delta_i)^2\right]^{\frac{1}{2}}.$$

Figure 7(a) shows 10 overlapping pulse waveforms when the load resistance is 35 Ω. As can be seen, the 10 pulses overlap exactly. The time marker in the figure is 10 MHz. To measure the jitter time we expanded the time marker to 100 MHz and reduced the load resistance to 12.5 Ω. The entire loop was then in a weak damping state. Figure 7(b) shows the 10 pulses recorded on the same film. The rms jitter time is about 3 ns. Since the start of the laser pulse on the OK-19 oscilloscope has about 3 ns of fluctuation, the laser triggered spark gap jittor time is therefore less than 3 ns. In the above experiment the laser power density incident on the optical fiber is 158 MW/cm^2 and the spark gap is charged to a voltage of 90 percent of the self-breakdown voltage. Like the delay characteristics comparison, we again compare the above results with the jitter characteristics of an electrically triggered spark gap. When the gap is charged to a voltage of 80 percent and 90 percent of the breakdown voltage, the jitter times are respectively 50 ns and 15 ns. Under our experimental conditions, the use of the laser triggered spark gap has reduced the jitter time by one order of magnitude or more.



(*a*) Dummy load resistor is 35 Ω (*b*) Dummy load resistor is 12.5 Ω

Figure 7. Voltage waveform on dummy load

Using the layout of Figure 5, a laser beam can trigger two spark gaps simultaneously. The two sets of capacitors each discharge through a spark gap and a load resistor. The end faces of the two optical fibers of the same type are in the same plane. The laser beams are adjusted so that the incident laser power densities are both 160 MW/cm^2. The discharge signals measured by the voltage dividers are fed into the two synchronized sweeps of the OK-19 oscilloscope. The jitter between the two voltage waveforms is observed on the oscilloscope. Experiments show that the rms jitter times of both signals are less than 3 ns, indicating a good synchronization between the two spark gaps.

IV. Conclusion

Using an ultraviolet XeCl excimer laser beam, we measured the transmission characteristics of Chinese made quartz fibers. The measured transmission loss is 0.2-0.25 dB/m at a wavelength of 308 nm using a 70 ns wide laser pulse and an incident power density of 20-200 MW/cm^2. This transmission loss is close to the 0.09 dB/m estimated from Rayleigh scattering.

The ultraviolet laser beam passes through the optical fiber and then triggers a spark gap. When the spark gap is charged to 90 percent of the breakdown voltage, the jitter time is less than 3 ns. The same laser beam may pass through two optical fibers and trigger two spark gaps with a high degree of synchronization. This technique may be applied to high power pulsed discharge gas lasers, free electron lasers, high energy accelerators, and short pulse laser oscillation and amplification systems.

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19 NOVEMBER 1986

China Report

SCIENCE AND TECHNOLOGY

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19 NOVEMBER 1986

CHINA REPORT

SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

IMPLEMENTATION OF TECHNICAL CONTRACTING SYSTEM DISCUSSED

Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 3, 1986 pp 28-32

[Article by Chen Changhui [7115 2490 1741] of the Science and Technology Bureau, Ministry of Aerospace Industry: "On Problems Associated with the Implementation of Economic Responsibility System for Technical Programs at Research Institutes"]

[Text] The reform of the funding system to research institutes is an important measure in the reform of the S&T system. In order to adapt to this reform, research institutes must implement various technical economic responsibility system centered around contracting based on scientific management methods. The following is a discussion of several problems associated with the implementation of this technical economic responsibility system by research institutes.

I. Necessity of Implementing Technical Economic Responsibility System

In the past, the Chinese government paid for all research expenses. There are serious drawbacks associated with the distribution of research money since everyone is getting funded from the same pool of funds.

1. There is no economic pressure at research institutes. The assignments are handed down from above and the funding also comes from above. The accomplishments are also reported to superior organizations. Thus, technology is detached from economics and scientific research is separated from production. This affects the wide application of research accomplishments.

2. There is a lack of scientific basis and rigorous proof in the distribution of funds. Most of the time, the money is split based on historic levels. Thus, the research assignments are not in sync with fund distribution. Projects with higher allocations often spend the extra money on other items. Projects with insufficient funding cannot keep with the schedule.

3. Research funding is managed out of phase with spending. The technical personnel only spend and do not manage. Whatever is spent is getting reimbursed. Research funding is not rigorously controlled. However,

research expenses and materials consumed are somewhat flexible in nature. Waste will occur if the technical staff does not consider the economics.

In order to overcome these problems, the funding system must be changed. Externally, we must implement a technical contract system. Internally, we must have a technical economic responsibility system.

This reform was implemented in several experimental sites for a few years. The experience shows that the management of research funding is improved and some research money is saved. The research people have a stronger sense of responsibility and the efficiency of research is improved. For instance, after implementing the responsibility system for the development of a certain product in our ministry, the research staff followed a strict budget to save expenses. In addition, the organization was managed based on system engineering principles. The result is that the development time is reduced by two thirds as compared to that of a similar project prior to the implementation of the responsibility system. The cost is saved by one half as well. The implementation of this system also encourages the research institutes to be oriented toward the economy and the society. It will break them away from department ownership and locality ownership, and will alter the various dependencies under the present structure. It will promote the linkage between research and production to allow technical accomplishments to be rapidly applied to manufacturing so that they can be converted to profits and social benefits. In the mean time, new sources for research funding are created. For example, a certain research institute in our ministry had a pure annual profit of approximately 2,000,000 yuan in 1983 and 1984. Due to the implementation of the reform, the 1985 profit is expected to be over 5,000,000 yuan. The institute created a research and development fund and a collective welfare fund from the profit. The government has reduced its support by 15 percent.

II. Methods for Implementing a Technical Economic Responsibility System

To implement a technical economic responsibility system and external contract system, we must bring economic and management concepts into the domain of scientific research to directly link research assignments with expenses. The technical and economic responsibilities of the research unit must be clearly identified so that responsibility, power and benefit are combined.

The ministry issues the research assignments to the institutes. The ministry signs a primary contract with the lead organization which then signs various lateral subcontracts with other collaborating units (or subcontractors of various systems). The contract must specify the tasks, accomplishments, schedules, costs and bonuses. Under the premise that the completion of all contracts within the ministry must be ensured, the institute can sign lateral contracts with outside organizations to face the economy and the society. Within the institute, all contracting responsibilities are assigned to various levels and individuals. The following is a discussion on the methods employed to implement the economic responsibility system in the institute.

1. General Contract Method

Different contracting methods should be applied to different research laboratories and shops. The situation is introduced in the following:

a. Major laboratories and machine shops, because of their ability to undertake research and production assignments of specific directives and to accept external contracted work, have their own incomes. They should be treated as independent accounting units, responsible for their own profits. The contracts should primarily contain targets specifying the research and production items as well as incomes. The research funding is determined by subtracting a specific proportion of the contracted amount for a risk fund and for management fee. At the end of the year, or upon completion of the project, a portion is set aside as bonuses based on the status of the assignment and on the net income. There are two ways to set the bonuses. One is to assign different percentages to net incomes derived from contracted targets and additional objectives, respectively. This is done either to encourage bringing in more work, to receive more income, or to ensure the completion of research projects in the plan. Each unit can decide its own priority based on its own situation. The other way is to bundle planned and unplanned projects together to arrive at a goal. Only one percentage is set for bonus payoff. This is a more convenient way to manage projects. In addition, it can prevent laboratories and shops from diverting costs incurred in contracted work of their own to projects planned by the institute.

b. A total duty responsibility system can be implemented with service-oriented laboratories and shops such as information research offices, instrument laboratories, chemistry laboratories and machine shops. (Their assignments are mostly service-oriented in support of major laboratories and shops in the institute. They can also accept outside work to receive technical service and service income.) The personnel, positions, and resposibilities are fixed. They receive compensation for some of the services rendered. On the basis of overall evaluation, bonus is given based on the completion status of the contracted tasks. A portion of the income from external services rendered is set aside for the employees as well.

2. Contract Method Based on the Implementation of Economic Objective Management

Because of the need to gradually reduce government support to achieve economic independence, research institutes in the technology development mode can implement the economic objective management system. The net income of the institute should be determined based on the amount of operating expenses to be saved each year. Based on factors such as the total wages of the people working on the first line of research and production, fixed capital, occupied area and liquid assets, the economic goal of the entire institute is broken down level by level to determine the amount to be undertaken by each unit, including directive research and production assignments. This method can stimulate the research laboratories and machine shops to actively tap into potential resources, save expenses, and add new projects to make the institute economically independent. Nevertheless, too much stress on economic objectives can make the institute go astray from the direction of scientific research.

3. Contracting Single Project

Some important research projects which involve several departments can be contracted to the task groups. By implementing the system of fixing the assignment, accomplishments, schedule, expenses and bonus in the contract, these projects can be directly managed by the institute. If other laboratories or shops are involved in some tasks, they can sign subcontracts with the task team. The leaders of such teams must be chosen by the institute. When appropriate, we can also try a bidding method.

III. Organization Management with Implementation of Technical Economic Responsibility System

The implementation of a technical economic responsibility system with lateral and serial contracts for research projects will make it easier to organize research based on systems engineering methods. It will also facilitate the coordination of various tasks. However, we should not neglect management because we implement the contract system. On the contrary, because economic and management concepts are brought into the domain of research, management will have to cover a wider range. The work becomes more complicated which requires better management. Specifically, we have to pay attention to the following points:

First, in the past, our primary concern was focused on technical feasibility and applicability and was not concerned with economics. To implement the technical economic contract system is to combine both for proof of technology and economics in order to ensure the accuracy of the research budget and the economic benefit of the project.

Second, there are more sources for projects after we make research face the society which adds a new dimension to organization management. The utilization and balance of research resources becomes more complex.

Third, as we implement the system to combine responsibility, authority and economic interest, to link technical accomplishments to economic gains, the personal welfare of the technical staff is affected. When the work is contracted, it will require tighter management and more rigorous inspection and review.

Fourth, due to the exploratory and uncertain nature of research, no matter how detailed the contracting work is done, there will be many unforeseen problems which require immediate coordination by the management.

Fifth, after implementing the contract system, each department is more concerned about its own interests and tends to neglect the overall picture. For instance, departments with general processing and testing equipment are happy to accept external work for additional income. They are not enthusiastic about assignments within the institute. Some departments will overload the equipment for more money. Some task groups would rather go outside because they feel the institute charges too much. Thus, the institute loses some funding. In order to save money, some task teams do not do enough experiments. Therefore, we must perfect the structure of the institute with specific reference to the problems emerging after the implementation of the contract system so that internally it is balanced and coordinated. Special favorable internal processing and testing rates must be established to promote collaboration and unity among all departments so that the institute is still one entity. In addition, management of technical quality must be strengthened.

The implementation of the technical economic responsibility system involves everyone. It requires the strengthening of three functional departments--planning, finance and maintenance. Furthermore, we must establish an effective technical control and command system.

The research planning department must handle the relations between what's needed and what's feasible, overall and local, focal points and general issues, progress and quality, and long term and short term well. It plays a leading role in assigning tasks. issuing contracts and rewarding accomplishments. The finance department must regulate, monitor and serve the institute to organize and manage the cost accounting work. In order to match planning with economic management to allow the proper management and utilzation of research funding, we need dedicated organizations and personnel to manage research funds. In general, we may set up a technical economics office under the planning department. The maintenance department must properly manage the instruments and equipment to meet the requirements of the new system.

In order to make sure that technical and quality-related management work such as development planning, project demonstration, and technical coordination and review is done properly to ensure the quality of research, we cannot weaken the technical command functions headed by the chief engineer and chief designer in implementing the contract system. Moreover, it requires a close coordination with the administrative management system.

The overall research and production dispatch system is an important part of the administrative command system. Its duty is to integrate the responsibility and authority of the department which ensures the resources needed in the research into the assignment to effectively utilize them to guarantee the success of the project. A main dispatch office may be established under the research planning and management department. It may be comprised of leaders from the planning department, maintenance departments, laboratories and shops to form a central command system centered around research and production. The chief dispatcher, acting on behalf of the director of the institute, exercises the power to issue orders on regular or emergency basis to ensure the completion of the assignments. A temporary or emergency order may be considered as a supplement to the original contract. Emergency orders should be approved by the director of the institute.

In various stages of research, we must closely combine the technology with economics. In the proof of feasibility stage, we should fully demonstrate both technical and economic feasibility by involving technical, planning and economic talents to choose the optimal plan. In the design development stage, cost must be controlled by value engineering and cost-effect analysis methods. The allocation and utilization of research funding must be broken down, tracked, accounted for and analyzed in order to reduce costs in various stages. In the accomplishment certification stage, not only technical review must be made, but also economic and social benefits must be evaluated. Only by doing so, the technical economic responsibility system can be fully effective to improve the economic welfare of the institute.

The implementation of the technical economic responsibility system is an important step for a research institute which is changing from a pure research mode to a research and production management mode. Systematic reforms in the leadership system, organization structure, wage system, planning system, internal relation structure and political ideology must be made to make the transformation effective.

IV. Principles to Follow and Relations to Keep in the Reform

When the institute implements reform, we must insist that the direction of research is the most important issue. We must always think based on the goals of achieving more accomplishments, training more professionals, and creating more social and economic benefits. We must place the assignments given by our government and our superiors first. In addition, we should pay attention to strengthening our political ideology and spiritual civilization. We must insist on the principle of distribution based on work. The following three relations must be properly handled:

1. Proper Treatment of the Relation between Government, Collective Entity and Individual in Implementation of Consolidation of Responsibility, Authority and Interest

The core of the technical economic responsibility system is "responsibility." We must determine "authority" and "interest" based on "responsibility."

In the area of "responsibility," in the reorganization within our ministry in recent years, a comprehensive technical post responsibility system has been set up. It is a basis for implementing the technical economic responsibility system. However, it still must be perfected based on the new situation. In the area of "authority," the Ministry issued a ruling in September 1984 to expand the autonomy of individual business units. More autonomy is given in areas such as planning, personnel, finance and discipline. In terms of leadership system, most institutes employ a director responsibility system. In addition, the authorities of research teams and shops are also expanded. Some attempts were made to organize task teams by free choice. These measures also facilitated the implementation of the new contract system. In the area of "profit" it is primarily done through keeping a fraction in the institute and distributing bonuses to individuals. The Chinese Government specifies the bonus exemption limit and the bonus taxation method. Each operating unit also has rules and regulations governing bonuses. In terms of bonus allocation, the size of the bonus will certainly affect individual enthusiasm. Nevertheless, the key is to overcome the idea of even distribution. It should be allocated based on performance. The bonus gap should be widened reasonably. Currently, bonus allocation is made based purely on profit. Due to the unreasonable social value system, different profit margins for each product, different environments, and other factors, this method may result in unequal rewards for equivalent amounts of work. Based on a survey, the difference is of the order of six- to eightfold. Such unreasonable gaps will affect the enthusiasm of some employees. In order to minimize this gap and to maintain relative internal balance, some institutes also collect a bonus tax from the basic departments based on the method implemented by the government to regulate the imbalances.

When we handle the relation between our country, the institute and an individual, we must strengthen the political ideology work to rectify the misconception that "money is everything." We must combine the evaluation of the technical economic responsibility system with the realization of spiritual civilization. We have to link the evaluation results with performance appraisal and promotion so that the consolidation of responsibility, authority and welfare is realized in a wider perspective.

2. Careful Handling of the Relation between "Building Foundation" and "Catching up With the Norm" with Economic Benefit in Determining the Guiding Business Strategy

After we opened up the institutes and expanded their authorities, there are two situations to be concerned about in the choice of tasks and in the guiding business strategy. One is that tasks related to "foundation building" and "achieving the norm," because of the degree of difficulty and length of duration, are not economically attractive in the short term. Nobody wants to undertake such assignments. Everyone is interested in tasks with short cycle, high profitability and of appropriate technical standards. In some cases, people abandoned research and got into business to make money. The other extreme is to be detached from current resources and blindly pursue leading high technology items by ignoring the economic benefits of the short term, appropriate level, profitable projects. Both extremes must be avoided.

When the relation between "level" and "economic benefit" is treated, we must base on an analysis of the specific situation. Institutes with better foundation and resources, under the premise of facing economic construction and emphasizing economic benefit, must strengthen their involvement in the exploration of new technology and focus on long range projects and technology reserves in order to maintain their advantages. Institutes of weaker foundation and poorer resources must be practical. They should realize that although the majority of those short term, appropriate level projects does not belong to high technology, yet they are small, highly specialized, highly profitable technologies needed to vitalize the economy.

During the early stage, regardless of the foundation of the institute, the desire to improve the economic benefits is more urgent. It is natural to do the easy and profitable tasks first. This is not only a current need but also an unavoidable process in the transformation from a closed to an open type of research institute. During this process, we can adjust to the new management system, explore new avenues, get into new habits, and accumulate required experience. However, as the technical business grows, low level projects will be less competitive. Research institutes will be forced to raise the standards and improve technology reserves.

3. Appropriate Treatment of Relation between Fundamental Management and Reform

Some fundamental management is required to implement the technical economic responsibility system. Through the reform, fundamental management can be further perfected. These two things are complementary. In reality, once we talk about "improve economic benefit" and "be flexible," we are anxious to make money. The existing management system and operating procedure which are still valid and current are being set aside. For instance, a project may be initiated without going through rigorous technical and economic proof of feasibility. In some cases, the quality control system is inadequate, leading to repeated work. In some cases, speed is the only concern and the accumulation of original technical and economic data is ignored. If these things are not rectified in time, the reorganization results over the past several years will be irrevocably lost. Scientific and economic laws must be obeyed for the reform to strengthen fundamental management work.

There is much work in fundamental management. However, based on implementing the technical economic responsibility system, first we must perfect the technical post responsibility system, as well as other rules and regulations, according to the needs of reform. In particular, we must incorporate contents in economic management and development to be implemented thoroughly. Second, we must strengthen the statistical work. We have to hire people, set up a system, perfect the research statistic indicator system, and establish the raw data forms and tables to create a complete statistical network. Then we must accurately calculate the cost. Through projection, planning, control, accounting, analysis and review, the cost and economic benefit of a research product are reflected. We should promote to combine technical and economic considerations to save expenses and reduce cost. To do a good cost calculation, we need to do a thorough inventory, formulate an internal pricing structure and depreciation schedule, define contents covered by the audit, clarify the roles of each functional department in cost management and accounting, establish an audit system and internal billing system, and prepare to keep good original data. The Ministry has already formulated a cost management and estimation method for research organizations. It will be implemented on a trial basis on 1 January 1986. The cost estimation work at research units will be initiated by the implementation of this method to further perfect the technical economic responsibility system.

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MICROCOMPUTER USE AS FURNACE CONTROLLER DESCRIBED

Beijing DIANZI JISHU YINGYONG [APPLICATION OF ELECTRONIC TECHNOLOGY] in Chinese No 2, 25 Feb 86 pp 6-9

[Article by Wang Dexi [3769 1795 3886] and Song Jian [1345 0256], Research Institute No 13, Ministry of the Electronics Industry: "The Application of Microcomputers in a High Temperature Molybdenum Element Furnace Control System"]

[Text] Introduction

Among semiconductor manufacturing techniques, the sintering of raw ceramic needs to be done in a molybdenum element furnace at temperatures up to 1,750°C. Molybdenum element furnaces are characterized by high temperatures (up to 1,800°C) and high power (tens of kw), and their control systems generally use the manually adjusted SCR output power method. Because the resistance of the molybdenum in the heating elements changes greatly as the temperature changes (as for example in the furnace we use when at 20°C the resistance is 0.017Ω, while at 1,750°C the resistance is 1.5Ω), in order to control the temperature and safeguard the equipment, operations personnel must regularly adjust the output power. Within a furnace operation time of 12 hours, operations personnel may not leave the premises. Nor can the accuracy of temperature control be guaranteed, as it oscillates ±20°C. Because there is always a large flow of protecting H_2 gas in the furnace, this provides an unfortunate factor in controlling temperature. After the system in question used a microcomputer for control, there was a great improvement in performance, where single-point control accuracy reached 1,750°C ±0.5°C, where the constant temperature area within 200 cm is ±3°C, where the rate of product finishing has reached 99.5 percent, and where at the same time labor intensity has been reduced. The system has excess temperature/cut-off thermocouple protection, and will sound an alarm. The rate of heat rise and temperature constant times may be set according to technical requirements, and the temperature can be maintained at any temperature. In addition, as conditions warrant, all set values may be changed without affecting program operation. Temperature control is via the PID adjustment method, where to avoid integral saturation PI and PD disconnect-type control is used. Data collection is via digital filtering. To avoid the difficulty where changes in molybdenum element resistance is too great, the stepped change of mid-values method is used, which allows optimal control of the furnace throughout the temperature range.

II. The System Hardware Composition

System hardware is made up chiefly of a microcomputer, process input channel, process output channel, printer, digital clock timing circuit, alarm circuit, and power supply circuits. The microcomputer is a DJS065A microcomputer, the CPU for which is the MBL6800, which has an instruction set compatible with the domestic DJS-060 series as well as with the imported 6800 series. Here, we have used only the single board computer part of the computer and the interface expansion board. The interface expansion board (I/OC board) has three parallel interface PIA MBL6821's, as well as the user parallel interface on the original board, which provides a total of four chips for the user to use. This computer has two MBM2716 EPROM's, for a total of 4K bytes; 2K bytes of the ROM is written with the monitor program, which leaves 2K bytes to be programmed by the user. There are 4K bytes of static RAM altogether, of which 1K bytes are used as stack for the monitor and the other 3K bytes are available for use. The system hardware flowchart is as shown in Figure 1.

1. Process Input Channel

The process input channel is outlined by the dotted line in Figure 1. This includes circuits for temperature sensing components, A/D converters, and isolating gates.

a. This system is largely used at present for controlling a high temperature molybdenum element furnace, where the regular temperature is 1,750°C, the corresponding temperature sensor for which is tungsten-rhenium thermocoupler, where the thermocouple potential corresponding to temperatures of 0°C≈1,800°C is 0≈28,030 microvolts. The change in thermocouple potential corresponding to each change of 1°C above 1,500°C is 13 microvolts. Because at the time this system was designed there was still no 16 bit A/D converters, we used the 5 bit semi-digital voltmeter BS18A to substitute for an A/D converter. We used the 0.15 V part of the voltmeter, the least bit of which can detect 1 microvolt.

b. Signal Gathering

The output of the A/D converter is a 5 bit BCD coded signal, in all a 20-bit binary numeral, and when a parallel interface expansion board is added to the computer then a sample signal can be input once at the same time. By not using time shared gathering control circuits, but by adding a software digital filter, we have strengthened the reliability of the system.

2. Process Output Channel

As shown in Figure 1, this is composed of the PIA 2 B circuit, the PIA 3 A and B circuits, separator gates, D/A output and display, mid-value output and display, point of inflection display, adder, power source and voltage compensation, and silicon controlled flip-flop circuits.

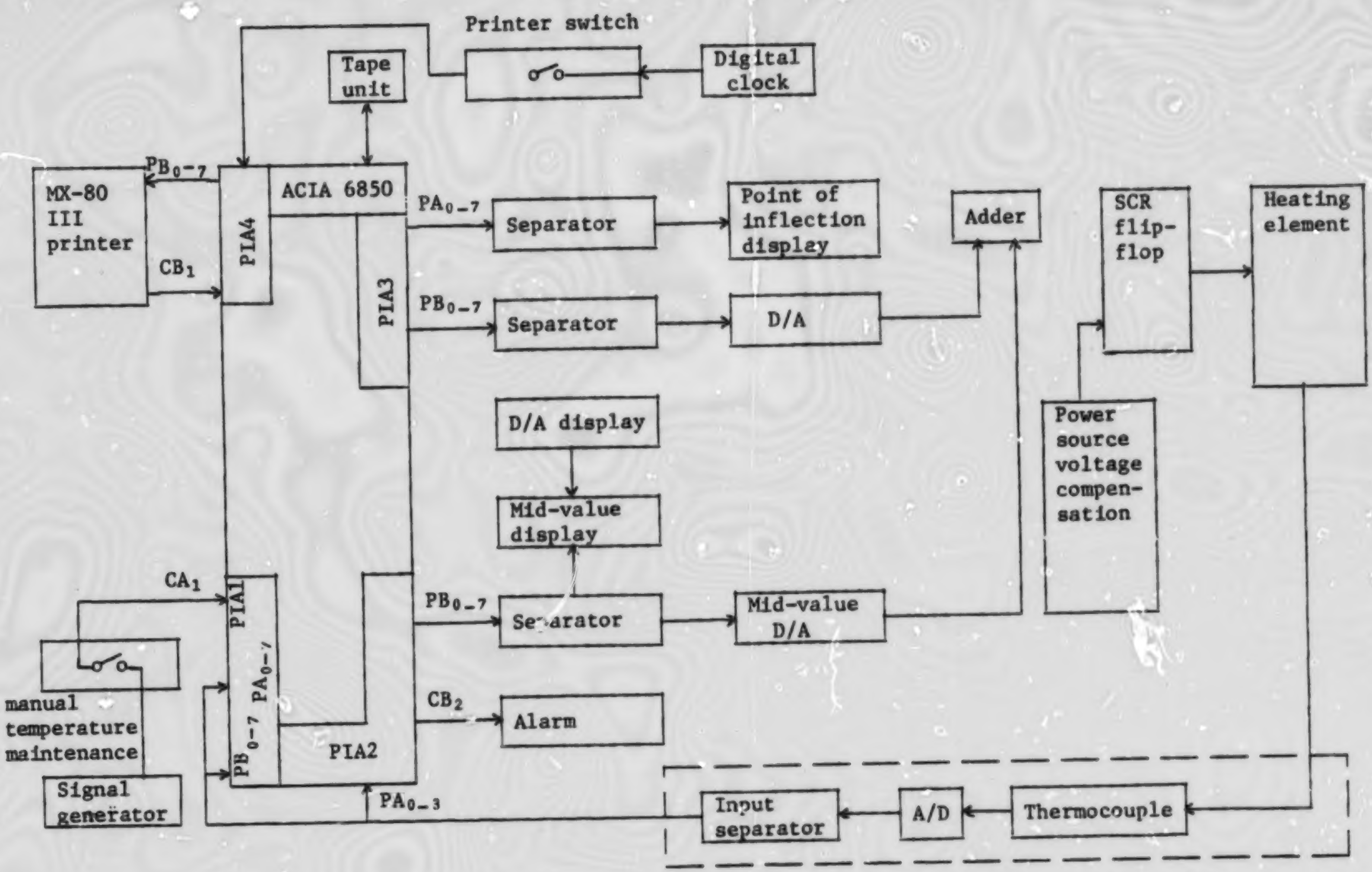
Printer switch
Tape unit
Digital clock
MX-80 III printer
PB_{0-7}
CB_1
PIA4
ACIA 6850
PIA3
PA_{0-7}
PB_{0-7}
Separator
Separator
Point of inflection display
D/A
Adder
SCR flip-flop
Heating element
Power source voltage compensation
D/A display
Mid-value display
CA_1
PIA1
PA_{0-7}
PB_{0-7}
PIA2
PB_{0-7}
Separator
Mid-value D/A
CB_2
Alarm
manual temperature maintenance
Signal generator
PA_{0-3}
Input separator
A/D
Thermocouple

Figure 1. General Diagram of System Hardware

a. Mid-Value Output Channel

Output in this system includes two parts: mid-value and D/A. In fact, mid-value is also D/A, and the D/A does not change for a particular segment of temperature area. Because the molybdenum element resistance will increase 100 times from room temperature to 1,750°C, this is not like controlling an ordinary furnace where full power raises the temperature, but rather the method of depending upon changing mid-values is used to safely reach the temperature goal.

It can be seen from Figure 1 that output is through channel B of PIA and that it is an 8-bit binary value, which means that it can divide the heating power into 255 portions. Passing through the separator gate, one circuit drives an 8-bit LED, which displays the size of the output, and the other circuit connects to the mid-value D/A board. The D/A board is 12 bit, and according to need, we can connect the 8 bits of the PIA to the corresponding bits of the mid-value D/A. Because the 12-bit D/A is greater than the 8-bit output of the PIA, we can in this way flexibly select the size of the output. After the mid-value output is added to the combination of the adder and the incoming D/A channel signal, the output then goes to the silicon controlled flip-flop circuit. Also, fluctuation of the power source voltage is added to the flip-flop circuit through hardware for use in high-speed compensation.

b. D/A Output Channel

Circuits in this portion are basically the same as those in the mid-value output channel, save for the fact that in the D/A output channel the 8-bit binary value output by circuit B of PIA 3 is the amount of adjustment output by the computer after the PID operation, and normally that is fluctuating. Because the D/A board is 12 bit, power trimming can be as fine as 1/4095, which is beneficial to ensuring control accuracy.

c. Point of Inflection Display Channel

This outputs an 8-bit binary value through circuit A of PIA 3 and drives eight LED's through the separator gate. It displays which temperature areas are currently rising in temperature or are constant in temperature. This can display the rising and stable temperature states at eight points of inflection.

3. Interactive Equipment

a. DJS-065A Microcomputer

After the system is operational, beginning from the left of the computer display the first four positions will always display a hexadecimal value for the furnace temperature, which will correspond to the decimal value on the digital voltmeter. When the parameters need revising during operation, the STOP button may be pushed, which will temporarily halt operations. At this time, output will be maintained unchanging and the parameters can be revised or data can be examined. When finished, it begins again from the temporary halt program, and the system continues to operate.

b. MX-80 III Printer

We have selected the MX-80 model III dot matrix printer, and after the digital clock has generated a timing interrupt signal, the printer then prints out the millivolt value corresponding to temperature value at that time, and will at the same time print out the temperature curve.

The timing signal can be set on the clutch plate from 1 to 60 minutes, and if arbitrary printing is needed the clutch plate can be moved to print out the millivolt values of the temperature for that moment. If printout is not needed, the printer switch can just be turned off.

c. Other

This system is also fitted with manual and automatic switching. When extraordinary conditions arise (such as excess temperature or thermocoupling), sound and light displays will automatically output that voltage has dropped to 0 volts. At this time, the situation can be handled by operations personnel by turning off the machine or switching to manual adjustment of output power.

III. Mathematical Modeling of the System

1. Adjusting Object Characteristics and a Flowchart for Controlling the System Transfer Function

Ordinary electric heating furnaces are first-order inertial links, and this high temperature molybdenum element furnace is no exception, also being of the first order inertial link. Its transfer function is:

$$W_1(S) = K_1 e^{-\tau_1 S}/(1 + T_1 S) \tag{1}$$

By measuring the rising curve of the furnace through experimentation, the amplification multiplier K_1 of the systemtransfer function can be found to be 10, the time constant T_1 = 600 seconds, and the delay time τ_1 = 30 seconds.

The system transfer function flowchart is shown in Figure 2.

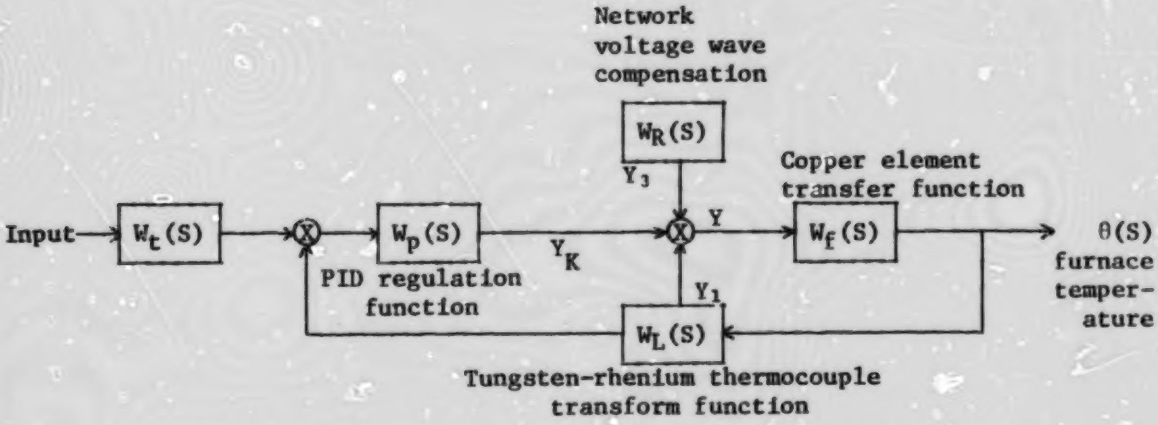
Network
voltage wave
compensation
$W_R(S)$
Y_3
Copper element
transfer function
Input
$W_t(S)$
$W_p(S)$
Y_K
Y
$W_f(S)$
$\theta(S)$
furnace
temperature
PID regulation
function
Y_1
$W_L(S)$
Tungsten-rhenium thermocouple
transform function

Figure 2. Flowchart of System Transform Functions

In the figure, $W_t(S)$ is the input transfer function and is the group of broken lines determined by the process curve; $W_L(S)$ is the thermocouple change transfer function; $W_R(S)$ is the power network voltage fluctuation compensation function; $W_f(S)$ is the transfer function for controlling the target high temperature molybdenum element furnace; $W_p(S)$ is the transfer function of the microcomputer's PID operation.

The overall controlled output quantity is:

$$Y = y_1 + y_k + y_3 \tag{2}$$

where y_1 is the mid-value quantity and a particular corresponding segment temperature does not change value. y_3 is the proportional feedback value determined by the hardware. The key here is to find the value y_k in the PID operation of the microcomputer.

2. Regulation Rules and Digital Filter for Sampling Data

The ideal method of regulation for first-order inertial systems is proportion-integration-differentiation, that is, the PID regulation method, and the ideal calculation method by which to simulate regulation is:

$$Y = K_p[e + (1/T_1)\int edt + T_d(de/dt)] \tag{3}$$

The PID form of calculation for the discrete sampling equation is:

$$Y_k = K_p\left\{e_k + (1/T_i)\sum_{i=0}^{k} e_i\Delta T + T_d\ (\Delta e_k/\Delta T)\right\} \tag{4}$$

Y_k -- regulation value for PID K-order output
K_p -- proportional coefficient
T_1 -- integration time
T_d -- differentiation time
ΔT -- sampling time
e_k -- the deviation signal obtained by K-order sampling
$\Delta e_k - e_{k-1}$

where e_k is the deviation between the sampled measured value and the given value. In general, this value will be rather small when the system has entered operations in the vicinity of stable values. Therefore, interference cannot be neglected. Sampling is as in the following digital filter equation, which basically prohibits the effects of interference. We proceed this way with one signal; that is, we successively sample five times, then eliminate the largest and the smallest, then take the average value of the three remaining mid-values as the value at this time. But the difference e_k between this value and the set value is not taken as the deviation value at this sampling. Rather, the deviations of the preceding three occasions are averaged with this deviation and substituted for the deviation value at this time. Showing e_k, we get

$$\bar{e}_k = (e_k + e_{k-1} + e_{k-2} + e_{k-3})/4 \tag{5}$$

$$\Delta\bar{e}_k/\Delta T = (e_k - e_{k-3} + 3e_{k-1} - 3e_{k-2})/6\Delta T \tag{6}$$

$\Delta e_k/\Delta T$ is the average value for deviation differentiation, so substituting first (5) then (6) in equation (4), we get:

$$\begin{aligned} Y_k = K_p\Big\{&(e_k + e_{k-1} + e_{k-2} + e_{k-3})/4 \\ &+ (\Delta T/T_I)\sum_{i=0}^{k} e_i + T_d(e_k - e_{k-3} \\ &+ 3e_{k-1} - 3e_{k-2})/6\Delta T\Big\} \end{aligned} \tag{7}$$

where K_p, T_1, and T_d can be roughly set up beforehand through K_f, T_f, and τ_f of the furnace transfer function as follows:

$$T_I = 2\tau_f = 60; \qquad T_d = 0.5\tau_f = 15;$$
$$K_p = T_f/(0.85K_f\tau_f) = 2.15$$

Accurate adjustments require that in actual practice optimal parameters be obtained, so at 1,750°C our final adjusted values are:

$K_p = 4$; $T_1 = 80$ seconds; $T_d = 20$ seconds.

IV. Applications Software

1. Main Temperature Control Routines

The flowchart for the main routines for controlling temperature is shown in Figure 3, which we now explain in the following points.

a. After PIA initialization and clearing of the working elements to 0, there is a delay of 2 seconds to allow the entire regulation period to be 3.2 seconds. This lets it match the control target and will also leave some time when in the future we control several furnaces.

b. Sampling of the temperature millivolt values is continued for five times (separation being 200 ms because the sampling period of the A/D converter is 200 ms), and after these five values have been digitally filtered they are used for identification. If this value is very small or equal to 0 it indicates that the thermocouple has already burned off or that there has been some other malfunction. The mid-values will be turned off, the D/A converter will be turned off, and an alarm will be sounded. If this value is greater than the number of millivolts in the thermocouple corresponding to 1,800°C, then this indicates excess temperature, and the mid-values and D/A will be turned off immediately, and an alarm sounded.

c. The final routines determine in order whether 1,500°C?; 900°C?; 600°C?; or 300°C? If the temperature is lower than 300°C, the production process does not need a rising temperature slope below 30°C, and also because at this time the furnace molybdenum resistance is quite small. To reliably raise the

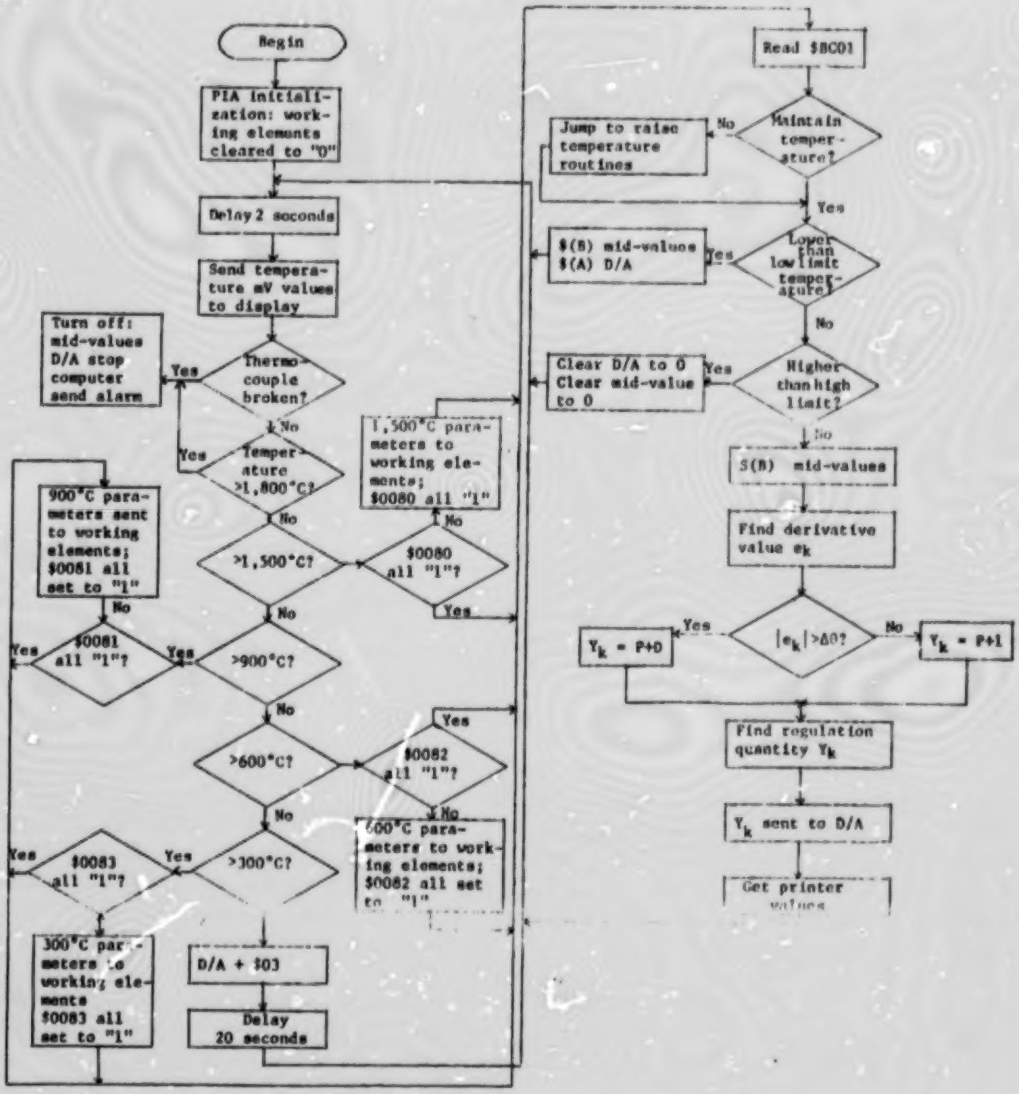
Begin
PIA initialization: working elements cleared to "0"
Delay 2 seconds
Send temperature mV values to display
Thermocouple broken?
Yes
Turn off: mid-values D/A stop computer send alarm
No
Temperature >1,800°C?
Yes
No
>1,500°C?
$0080 all "1"?
Yes
No
1,500°C parameters to working elements; $0080 all "1"
No
>900°C?
Yes
$0081 all "1"?
Yes
No
900°C parameters sent to working elements; $0081 all set to "1"
No
>600°C?
$0082 all "1"?
Yes
No
600°C parameters to working elements; $0082 all set to "1"
No
>300°C?
Yes
$0083 all "1"?
Yes
300°C parameters to working elements $0083 all set to "1"
D/A + $03
Delay 20 seconds
Read $BC01
Maintain temperature?
No
Jump to raise temperature routines
Yes
Lower than low limit temperature?
Yes
$(B) mid-values $(A) D/A
No
Higher than high limit?
Yes
Clear D/A to 0 Clear mid-value to 0
No
S(B) mid-values
Find derivative value e_k
$|e_k|>\Delta 0$?
Yes
$Y_k = P+D$
No
$Y_k = P+1$
Find regulation quantity Y_k
Y_k sent to D/A
Get printer values

Figure 3. Flowchart of Temperature Control Routines

temperature, the method of adding $03 to the D/A every 20 seconds is used to gradually increase the output power. When the temperature has exceeded 300°C, the entire temperature process is divided into four parts, which allows each segment to correspond to different mid-values (stored as element $B) and D/A (stored as element $A), ensuring that the power will not become too great and burn components.

d. Determines to which segment a temperature corresponds, then after filling in the parameters for this segment in the working element, by distinguishing whether the high bit of control register BC01 is 0 or 1, it is determined whether it is necessary to raise the temperature or to maintain it. If an 0, it indicates that there is no pulse input to jump to the raise temperature routine. If a 1, it indicates that there is a pulse input and processing is to be as needed for maintaining the temperature. Please note that at the end of the routines to raise temperature, they return to the temperature maintenance routines.

e. After jumping to the temperature maintenance routines, it is first determined whether the current temperature is lower than the low limit temperature θ_{low} that has been set. If it is lower than θ_{low}, then the mid-values and D/A are turned completely on (the mid-values and the D/A of the corresponding segment are not the same), which allows a rise in temperature at full speed; when the current temperature is higher than the upper limit temperature θ_{high} that has been set, then the mid-values and D/A are turned completely off for a reduction of temperature at the greatest speed.

Only when the temperature is between the set values θ_{low} and θ_{high} can the routines enter the normal range for controlling temperature, solving for the deviation value e_k. If the absolute value of e_k is greater than 5°C, PD control is used; if less than 5°C, PI control is used, which allows for a better control process. The control value Y_k is derived from PID calculations. It is used to regulate the furnace heater flow I_3, the total heating current of the furnace being composed of three parts:

$$I = I_1 + I_2 + I_3 \tag{8}$$

where I_1 is the mid-value current, corresponding to the temperature within a particular range, this current does not change. I_2 is the compensation current as determined by the hardware and the power source voltage reciprocal. I_3 is the control current as calculated by the microcomputer through PID calculations. Corresponding to any particular temperature, when the deviation e_k is 0, any value may be present. Above 1,500°C, the system routines are preset to 88, and when this value is added to or subtracted from the calculated Y_k, the result is sent to the D/A, which is the I_3 that we have derived.

f. The raise temperature routines rise linearly according to the set value, the furnace temperature reached by the principle of rising. The purpose is to allow the rising temperature curve to fit the process requirements.

2. Printer Routines

This temperature control system is provided with an MX-80 III printer, a dot matrix printer that is a product of the Japanese Epson Co. and that has been modified by the Tianjin Hongxing Plant. Printing is by means of interrupts generated to the computer. This computer provides the user with a screen interrupt IRQ (active low), as shown in Figure 1, and the signal to print is a timing signal (adjustable from 1 to 60 minutes) generated by the digital clock. Output generates an interrupt from the PIA 4 CA1.

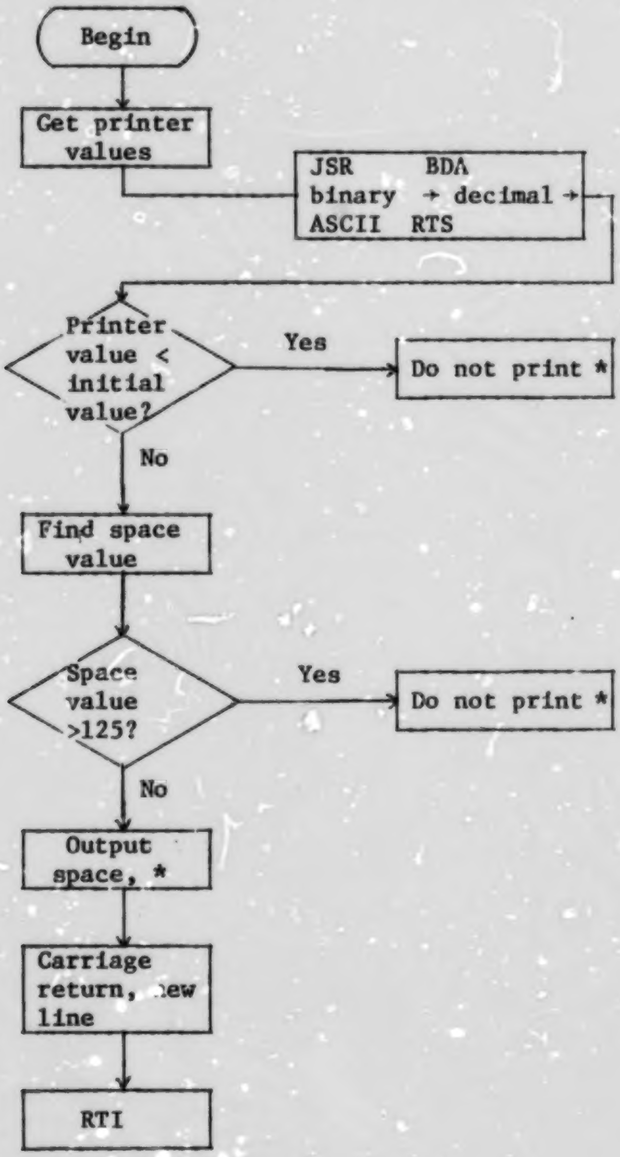
Begin
Get printer values
JSR BDA
binary → decimal →
ASCII RTS
Printer value < initial value?
Yes
Do not print *
No
Find space value
Space value >125?
Yes
Do not print *
No
Output space, *
Carriage return, new line
RTI

Figure 4. Flowchart of Print Routines

A flowchart for the printing routines is shown in Figure 4, some points about which we explain here:

a. The printer can only receive ASCII code, so after the binary values have been changed to decimal, they must still be changed to ASCII before outputting to the printer.

b. Because we are using compressed printing, there is a maximum of 132 characters [in a line], while the millivolt values for the temperature are five place decimal values, which leaves 127 character positions. We have allowed the largest available space to be 125, the hexadecimal value of which corresponding routine is $09C4.

c. The printing format is to first print out the decimal value of the millivolt value of the current temperature, after which is printed an asterisk. The position of the asterisk is determined by the following formula:

$$M = (T - A)/C \tag{9}$$

where M -- the output space value
T -- printed temperature microvolt value
A -- initial microvolt value
C -- the microvolt value represented by each space. These routines assume 20 microvolts.

We can see from equation (9) that there will be an asterisk printed after M number of spaces.

The initial value is chosen by the operations personnel, where it is placed at addresses $0210 and $0211, and if less than the initial value or exceeds 125 spaces, then it is not printed.

The printing routines inventory has been omitted.

V. Conclusions

The temperature controlling accuracy of this terminal is ±0.5°C (600~1,750°C); it can run for long periods. With slight modifications, this software and hardware can control several devices by itself. But as microcomputer prices get lower and lower, from the point of view of highest reliability we still hope to develop microcomputer single installation control systems.

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2. "Computer Controller Technology," Nanjing Academy of Engineering, 1980.

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5. "Microprocessor Devices and Microcomputers," Qinghua University, Li Sanli [2621 0005 4539], 1981.

6. "MX-80 Type III," Operations Manual, Epson.

12586/9365
CSO: 4008/1075

APPLIED SCIENCES

MICROCOMPUTER CONTROLLED ANALOG TESTING SYSTEM DESCRIBED

Beijing DIANZI JISHU YINGYONG [APPLICATION OF ELECTRONIC TECHNOLOGY] in Chinese No 2, 25 Feb 86 pp 18-20

[Article by Wei Fengwei [7614 7685 5633]: "Microcomputer-Controlled Analog Quantity Testing System"]

[Text] In any special field there must be accurate, error-free testing of analog electric quantities, and this must be quick and the instrumentation light and convenient. This is quite a high requirement for automated test equipment. By using microcomputers in the testing and control of analog quantities we can easily realize this requirement. Regarding the microcomputers, all they need are some hardware interfaces together with the corresponding testing software and they can then quickly and accurately accomplish the testing requirement in accordance with pre-arranged routines. They can also generate an alarm signal when volt or current have exceeded a standard. They can provide the location of the error, and the test results can be completely output to display or printer for file storage and analysis.

I. A Brief Description of the Testing System

The testing system is composed of the five parts that are the object to be tested, the controller instrument that is microcomputer based, the test instruments, a power supply, and output equipment. A diagram of the analog quantity test system is shown in figure 1.

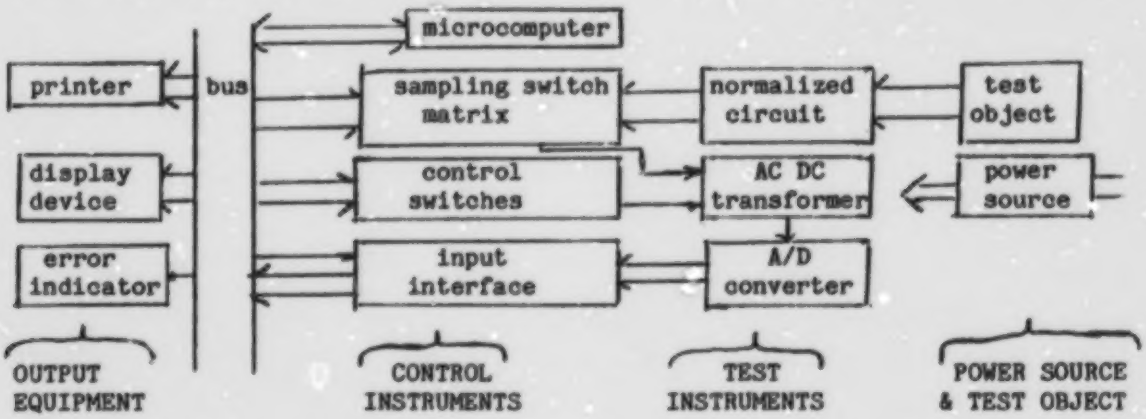
microcomputer
printer
bus
sampling switch matrix
normalized circuit
test object
display device
control switches
AC DC transformer
power source
error indicator
input interface
A/D converter
OUTPUT EQUIPMENT
CONTROL INSTRUMENTS
TEST INSTRUMENTS
POWER SOURCE & TEST OBJECT

Figure 1 Flowchart of Analog Quantities Test System

Control commands are generated by the user program in the EPROM on the microcomputer, which allows automated testing of multiple circuits and various kinds of signals. Each signal that is tested comes in through cables to the test instrument's signal normalized circuit, gated through multichannel analog switches and gates, sequentially sent into ac/dc transformer circuits and dual integrated A/D converters, and is then sent to the microcomputer via an input interface where it undergoes data processing before being output for display, when the test results are printed out. A partial power source schematic for this automated test system is given in figure 2.

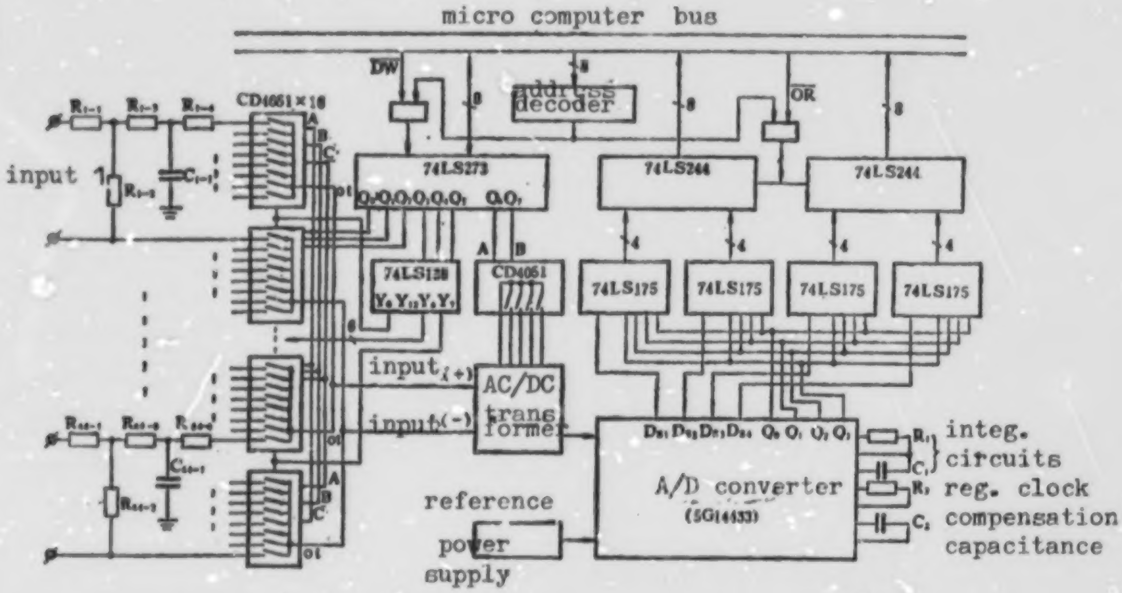
micro computer bus
DW
address decoder
8
8
8
OR
CD4051×16
A
B
C
input 1
R_{1-1}
R_{1-3}
R_{1-4}
R_{1-2}
C_{1-1}
74LS273
$Q_0Q_1Q_2Q_3Q_4Q_5$ Q_6Q_7
74LS244
74LS244
4
4
4
4
74LS175
74LS175
74LS175
74LS175
74LS138
$Y_0Y_{11}Y_8Y_7$
A
B
CD4051
6
input(+)
input(-)
AC/DC transformer
R_{16-1}
R_{16-3}
R_{16-4}
R_{16-2}
C_{16-1}
A
B
C
01
reference power supply
$D_{S1}D_{S2}D_{S3}D_{S4}$ Q_0 Q_1 Q_2 Q_3
A/D converter
(5G14433)
R_1
C_1
R_2
C_2
integ. circuits
reg. clock
compensation capacitance

Figure 2 Power Supply Schematic

a. The object of testing

The objects of testing can be electric signals that are the output from power supplies for electronic equipment and from voltage, current, and signal sources, as well as working points on an electronic circuit; all output current not less than 50 microamps; DC voltage signals of 0 + or - 40 volts; effective values of 25 volts of low frequency sinusoidal voltage; peak values of 40 volts of low frequency square waves, all of which can be tested quite accurately in this system. Length of the transmission cable is determined by actual conditions, the only requirement being that the internal resistance be as low as possible. Theoretically, the voltage values to be tested may be raised without affecting the tested accuracy. But if the tested source load capacity is quite weak, during the process of transmission the signal will be affected by interference, which will affect the accuracy of the test results.

b. The controller

The controller is composed of three parts: the microcomputer, a sampling decoder switch matrix, and an input interface.

The microcomputer used is a Z-8000 16-bit single board computer. But the TP-801 8-bit computer can also be used.

Sampling control is achieved through the 8-bit data lines provided by the microcomputer. The D6 and D7 among them are the status control bits, which two bits can decode four different codes. It can select four different working states of AC-DC transformer circuits: afterpulse, maintain peak value, maintain negative peak value, and maintain. Lines D0 through D5 are the sampling gate controller bits, through which can be decoded 64 different codes, used for controlling an 8 X 8 switch square matrix. There can be automatic gating and testing of signals on 64 circuits. The testing system described in this paper actually uses 40 circuits, the other 24 being for future use. The switch matrix uses the non-contacting electronic multiplexing analog switch CD4051.

The input interface is a 16-bit parallel input interface. Two levels of transfer have been designed for this system, with four 4D flip-flop 74L8175's acting as data buffers; two 8-bit tri-state latches, 74L8244, latch the computer's data bus.

c. The test instrument

The test instrument is made up of a normalized circuit, AC-DC transformer circuits, and an A/D converter.

The normalized circuit is actually a system input circuit that has been designed as an RC network with filter, current-voltage converter, and voltage level conversion functions. By adjusting the R1-2 ratio we can select the sampling ratio, allowing the input signal to uniformly become a voltage signal within a particular amplitude, to prepare for gating and testing.

The A/D converter is the key link in the test instrument. We have used the dual integrated A/D converter, 5G14433. This device is a product of the Shanghai Component Factory #5, and outputs BCD code. It uses analog zeroing, digital zeroing, repeated analog zeroing, integration of input voltage, and accomplishes first-order conversion of analog quantities-digital quantities for reference voltage integration, integrator constant-current discharge, and for counting within the current discharge time. R2 in figure 2 is used to adjust components connected to the clock frequency of the converter, as the clock frequency determines the speed of the A/D conversion. The conversion speed of this system is 4 times per second.

The AC-DC converter is a dual integrated A/D converter 5G14433 designed advance circuit. It function is to convert the normalized voltage signal to be a DC voltage signal of less than 2 volts, to prepare for modular conversion. The working process for the AC-DC converter is controlled by the computer, and four working states are automatically selected according to the requirements of the test signal.

d. Power supply

For the power supply a floating, dual shielded secondary power source is used.

e. Output equipment

1. A digital display device on the microcomputer; 2. a printer.

f. Functional set-up of the system

1. Sampling of the input signal is gated through control of the microcomputer, automatically gated according to the user-designed program.

2. Working states of the AC-DC converters are controlled by the microcomputer, automatically programmed to switch over.

3. Various reset coefficients and standard values for tested electrical quantities are programmed into the EPROM, so data handling proceeds automatically.

4. Actual values of tested signals can be read directly from the display device or from the printed results, the dimensions being identical with reality.

5. Automatic adjustment of zeroing.

6. Automatic initialization and both manual and initial reset.

II. A Flowchart of the Test Routines

A flowchart of the test routines is given in figure 3.

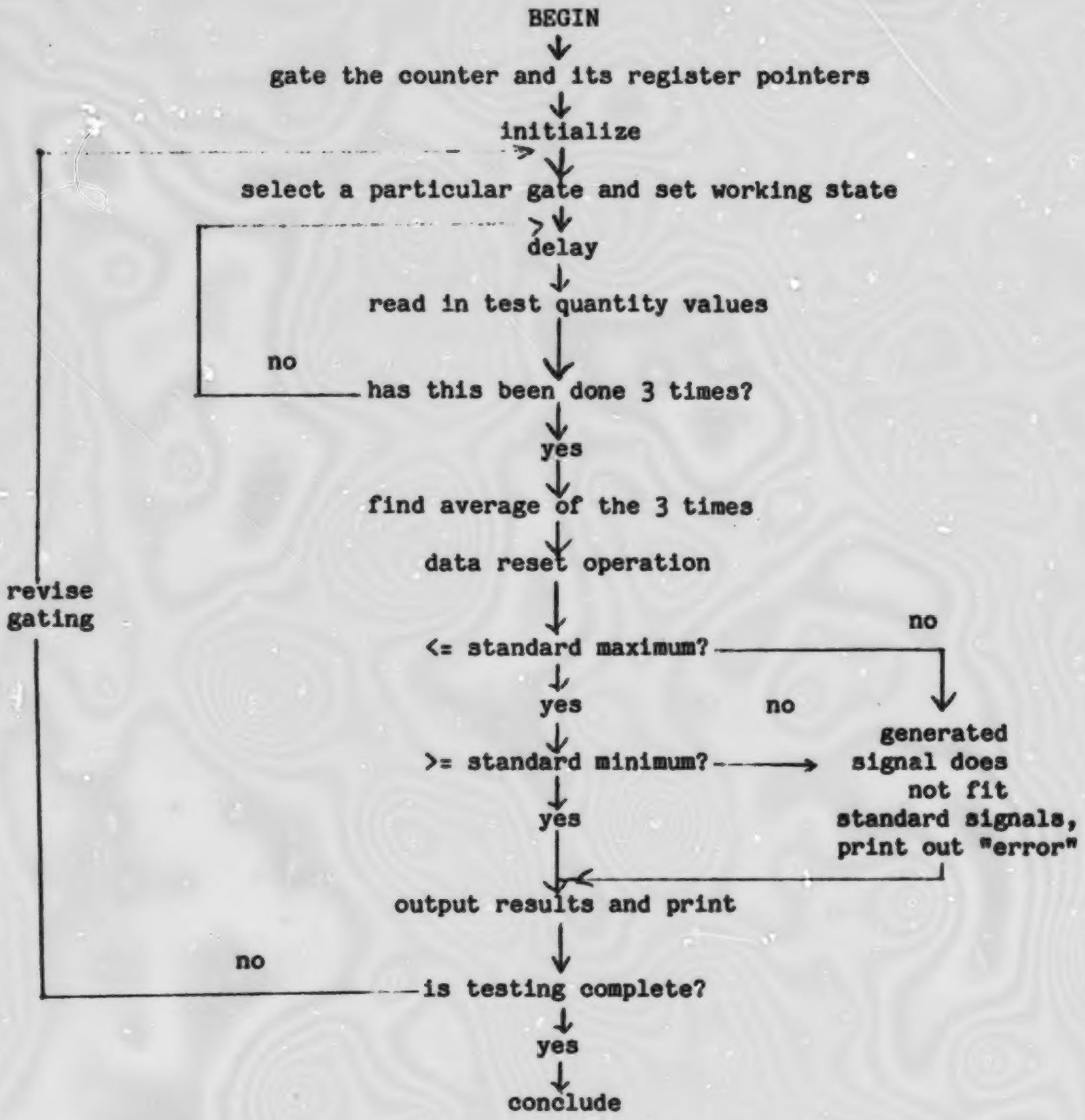
BEGIN
gate the counter and its register pointers
initialize
select a particular gate and set working state
delay
read in test quantity values
no
has this been done 3 times?
yes
find average of the 3 times
data reset operation
revise gating
no
<= standard maximum?
yes
no
>= standard minimum?
yes
generated signal does not fit standard signals, print out "error"
output results and print
no
is testing complete?
yes
conclude

Figure 3 Flowchart of Testing

III. Further Developments of System Applications

What we have discussed above is an automatic testing system controlled by a microcomputer. It can also be used for multimonitoring or relative constant control of physical quantities such as temperature, speed, and water pressure. As long as each monitoring point (or control point) of the object to be tested is equipped with sampling devices and electrical quantity converting devices that can convert the physical quantities to electrical quantities, it will work. The flowchart of the routines used for monitoring is shown in figure 4. The portion indicated by dotted lines in the figure are the places in the program process and monitor testing program process that are not the same when used for relative constant control, the identical portion having been abridged.

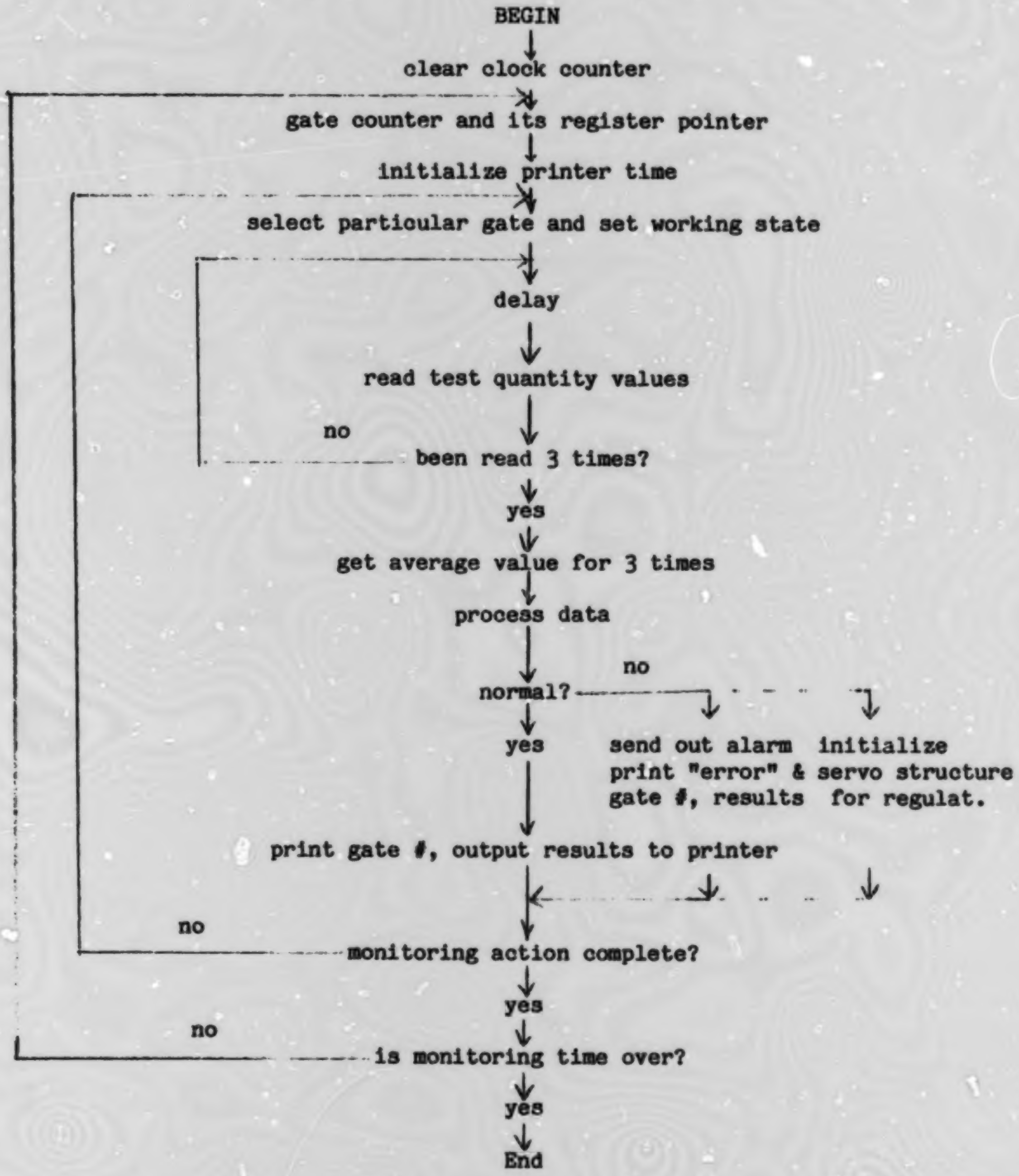
BEGIN
clear clock counter
gate counter and its register pointer
initialize printer time
select particular gate and set working state
delay
read test quantity values
no
been read 3 times?
yes
get average value for 3 times
process data
no
normal?
yes
send out alarm print "error" & gate #, results
initialize servo structure for regulat.
print gate #, output results to printer
no
monitoring action complete?
yes
no
is monitoring time over?
yes
End

Figure 4 Flowchart of Monitoring Routines

IV. System Anti-Interference Measures

Whether it is the testing of analog quantities or the process of monitoring or controlling, when examining the strengths and weaknesses of a system anti-interference capability is an important index. If the system is operating under harsh conditions, the relative strength of its anti-interference capability not only directly affects the reliability and accuracy of output results, but it even concerns the success of the system. To improve anti-interference capabilities in this system, we have taken the following measures:

a. We have chosen a dual integrated A/D converter that is highly resistant to interference;

b. Filtering links have been added to input circuits to prevent random high frequency pulse interference;

c. The microcomputer and test instruments both have high level shielded, floating secondary power supplies and automatically loop back to prevent common mode interference;

d. The differential input method is used to prevent ordinary state interference;

e. The transmission cable has twisted-pair shielded wire, and the test circuits are shielded, all of which prevents cross interference.

Experiments have shown that anti-interference measures used in this system are effective. When transmitting over a 150 meter line, test accuracy of the system is not degraded.

12586
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DISPOSAL OF SOLID RADIOACTIVE WASTE OF NUCLEAR POWER PLANT

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 7, No 2, Apr 86, pp 35-38, 74

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[Text] I. Introduction

During the operation of a nuclear power plant, most of the released radioactive elements with the exception of the low-poison group such as inert gases and tritium, are contained in the radioactive solid wastes. Therefore, management of radioactive solid waste is an issue of great importance.

The treatment of radioactive waste involves converting the waste materials into a form that is suitable for shipping, storage and disposal (including condensation, compression, solidification and packaging). The disposal of radioactive waste is to properly seal and store the waste so that before the radioactive elements decay to a sufficiently low level, they will be isolated from the human and biological cycles, and will never cause harm to human beings.

In 1983, the International Atomic Organization held a conference on radioactive waste management in Seattle, where 31 countries and 9 international organizations participated. It was generally believed that the basic technical problems of disposing low-radiation level waste materials had been solved, but further improvements are required to develop a complete waste disposal system[1].

II. Unique Features of Radioactive Solid Waste from Nuclear Power Plant

It should be pointed out that the radioactive solid waste from nuclear power plants does not include the exhausted fuel elements from the reactor or the high-radiation glass byproduct from processing exhausted fuel elements. A small amount of high-radiation waste such as replaced reactor parts are stored with the exhausted fuel elements where they undergo decay and then shipped out of the plant.

A small amount of solid waste (e.g., contaminated equipment and parts) may be treated as non-radioactive waste or reused after decontamination or storage and decay. Most of the solid wastes (e.g., solidified residual liquid from evaporation, filtered slush, filter core, wasted resin, burned ash, or other types of dry waste) contain more than 90 percent of the radioactive elements. These solid wastes are primarily low to medium radioactive elements with relatively short half lives and exhibiting $\beta - \gamma$ radiation; the content of super uranium, long half-life elements exhibiting α radiation is very low. The level of activated corrosive products such as ^{58}Co ($T_{1/2}$ = 71 days), ^{60}Co ($T_{1/2}$ = 5.3 years), ^{55}Fe ($T_{1/2}$ = 2.7 years), ^{59}Fe ($T_{1/2}$ = 45 days) is quite high, but because of their short half lives, generally they will have no adverse effect after storage for 50-100 years. The radioactivity after storage primarily comes from fission products ^{90}Sr ($T_{1/2}$ = 28.5 years) and ^{137}Cs ($T_{1/2}$ = 30.2 years).

The annual output of solid waste from a nuclear power plant depends on the reactor power, the type of reactors, the operation and management of the power plant, the condition of maintenance and repair, and the waste treatment techniques [2]. The amount of solid radwastes produced by a 1 million kW light-water reactor in the U.S. is 400-1300 m^3 per year [3]; a similar reactor in Japan produces (600-1000 m^3 solid radwastes per year [4]; and a 900,000 kW PWR of the French Framatome Atomic Energy Co. produces 400-500 m^3 solid radwastes per year.

The above discussion shows that the unique features of solid radwastes from nuclear power plants are: large volume (a 1-million kW PWR power plant produces 400-600 m^3 solid radwastes per year; a BWR power plant with the same reactor power will produce 70 percent more), and low specific radioactivity, most of which is attributed to short half-life nuclear elements with $\beta - \gamma$ radiation. According to the law of radioactive decay, the level of radioactivity is reduced by a factor of 1,000 after 10 half lives and by a factor of 1 million after 20 half lives. In other words, the radioactive waste must be isolated from human and bilogical cycles for 300-600 years.

III. Ocean Disposal

Ocean disposal of solid radwastes has the following merits:

1) The ocean is isolated from human environment;

2) The structure of the ocean floor used for waste disposal is geologically stable;

3) Because of the lack of free oxygen near the odean floor, the waste containers can remain intact for a long period of time without suffering oxidation;

4) The ocean emits a high level of natural radiation, even if there are leaks of radioactive elements from the disposed wastes, they will be absorbed in the fluctuations of natural radiation.

The Nuclear Energy Office of the Organization of Economic Cooperation and Development had studied the problem of ocean disposal of low radiation solid wastes, and had established guidelines and clearly defined monitoring responsibilities. Disposals of nuclear wastes in the Atlantic Ocean had been monitored by an international organization; specifically, at a depth of 5,000 m, five member nations had disposed 35,000 waste containers with a total weight of 11,000 tons and total radiation level of 8,000 curies. Subsequently, eight European countries (France, West Germany, Belgium, Italy, Holland, Switzerland, Sweden and Great Britain) participated in 11 ocean disposals; the average depth of disposal was 4,500 m [5].

In order to prevent the radioactive wastes from polluting the ocean, a conference was held in 1972 in London to discuss a treaty on ocean disposal. The treaty requires that each country establish a national-level organization to control the ocean disposal of wastes, ban the disposal of high-radiation wastes, and that disposal of low and medium radiation wastes must be approved and managed by a special office. It also establishes specific regulations for selecting the disposal sites, and requires that they must be at least 4,000 m deep, and must be away from continental mounts, deep-sea resources and underwater cables [6].

Based on an assessment of the radioactive ecology of disposed radwastes in deep ocean regions, the International Atomic Energy Organization has banned the ocean disposal of high-radiation wastes; all radioactive elements are classified, and those which exceed the threshold are banned from ocean disposal. An inspection of the disposal site in the northeast Atlantic Ocean shows that it meets the requirements established by the International Atomic Energy Organization.

Between 1946 and 1970, the United States opened more than 50 ocean disposal sites, 90 percent of the waste materials and 95 percent of the radioactive elements are concentrated in four of these sites, but they did not meet the specifications of the London treaty or the Organization of Economic Cooperation and Development. Since the method of shallow ground burial of solid radwastes was successfully developed by the Department of Energy, in 1970 the United States decided to stop ocean disposal of radioactive wastes in order to protect the ocean environment. In an environmental assessment of the four disposal sites, containers were retrieved from the ocean floor ranging from 2,800 m to 3,800 m in depth; careful inspection showed that the containers were compressed toward the center, and there were small amounts of radioactive elements surrounding the container; however, there was no evidence of damage to human beings or the ocean environment [7].

In 1949, Great Britain began disposing packaged containers of low-radiation solid wastes in the Atlantic Ocean; between 1967 and 1971, it participated in the experimental joint ocean disposal project sponsored by the Nuclear energy Office of the Organization of Economic Cooperation and Development, and accepted international monitoring. By the end of 1983, the total amount of ocean disposed waste materials reached 77.53 tons. They believe that ocean disposal will not lead to detectable danger, and therefore will continue to do so. They plan to invest in the renovation of disposal ships and installation of satellite navigation equipment; the amount of disposed radwaste is expected to increase at a rate of 20 percent per year.

In order to assess the safety of ocean disposal, Japan conducted high-pressure filtration tests and container integrity tests under simultated 5,000-m deep ocean conditions. It also conducted safety inspections of disposal sites.

In 1983, the London Waste Disposal Treaty Conference passed a resolution to ban ocean disposal of radioactive wastes, but this resolution had no real restraining authority. Protecting the ocean environment and preventing radioactive pollution has become a problem that is of concern to every nation in the world; a final resolution is expected to be reached during an international conference in 1985.

IV. Land Disposal

Land disposal of radioactive solid wastes is an effective method to protect human beings and the environment [8]; it accounted for 99 percent of the radwaste disposals in the past [9]. There are three different approaches to land disposal.

1. Shallow Ground Burial

The shallow ground burial approach is to bury the radioactive solid wastes in a trench which is 30-240 m long, 6-12 m wide and 6 m deep. The waste container is first covered with 1-3m of dirt then with a layer of clay; a stone or metal market will be erected to indicate the volume and radiation intensity of the disposed wastes. The United States has 6 commercial disposal sites which can accommodate 764,000 m^3 of solid wastes. Currently, all the low-radiation solid wastes produced by the nuclear power plants in the U.S. are disposed using the shallow ground burial approach. At some of the earlier burial sites, because of the crude construction and site selection, and poor packaging and management, there was evidence of leakage of radioactive elements. Upon detection by the monitoring system, the disposal sites were closed down immediately to avoid further damaging effects on the public and on the environment.

The construction and utilization of shallow disposal sites can be divided into four stages: 2-3 years of building the site facilities and digging the trenches; 15 years of disposal service; 150 years of monitoring and limiting land use after closing down the disposal site; after that the land can be used without any constraint. Because of the different conditions of hydrology and geology, the cost of building a disposal site differs considerably from one country to another.

In Great Britain, the Nuclear Industry Radioactive Waste Commission divides the waste materials designated for shallow ground burial into different categories; low-radiation wastes can be directly placed in storage tanks; medium-radiation waste tanks must be shielded with cement before shipping; waste materials with high β-γ radiation are stored in tanks and shipped to the disposal sites in shielded containers. The design guidelines for the burial trenches are:

a) selecting a trench site with the proper geological structure of with clay soil;
b) the sidewalls and bottom of the trench must be inclined;

c) water drainage ditches must be constructed around the burial trench;
d) monitoring holes must be installed in the vicinity of the trenches.

The first type of burial trench is 150 m long, 8 m wide and 6-9 m deep. The bottom of the trench is inclined toward the water pit, and is covered with a layer of 1-m thick gravel and sand for water drainage. When the waste materials reach a height of 3-5 m, they are covered with clay to minimize water infiltration.

The second or third type of trench is 70 m long, 20 m wide and 19 m deep. The bottom of the trench is inclined toward the water pit, and covered with a layer of porous cement; the water pit is equipped with monitoring tubes, and the trench walls are constructed with steel reinforced concrete. The shielded waste tanks are lowered into the trench using a fork lift; after reaching a height of 8 m, they are covered with a 1-m thick steel-reinforced concrete and coated with a layer of water-resistant asphalt, then filled with a layer of 3 m-thick packed clay. On top of the trench is a 1 m-thick steel reinforced concrete structure covered with a layer of of 5 m-thick packed clay to prevent rain water from entering.

In France, the disposal of solid radwastes from nuclear power plants is the responsibility of a national radwaste management bureau. The [wangshen] radwaste storage pool located in northwest France has a storage capacity of 400,000 m^3; since storage began in 1969, 200,000 m^3 of it has been filled. In France, the solid radwastes produced by a nuclear power plant are stored inside the plant for 15 days before being shipped to the national waste pool for disposal.

2. Storage in Abandoned Mines (or Caves)

This form of storage is primarily used by small, densely populated European countries with stable geological structure. The abandoned [Hesai] salt mine in the northeast part of West Germany is free of ground water and geologically stable; it has an area of 4.2 square kilometers. In a region 490-750 m below the surface, 130 chambers were excavated with a total capacity of 3.6×10^6 m^3; they can accommodate 140,000 barrels of low-radiation wastes and 1,300 barrels of medium-radiation wastes.

Abandoned mines generally have sufficient depth to have any effect on human activities. But they were designed and constructed to meet mining requirements; whether they are safe for disposal of radioactive wastes remains to be investigated.

3. Storage at the Plant Site

In technical report No. 198 of the International Atomic Energy Organization, "Guidelines for Safe Treatment of Radioactive Wastes of Nuclear Power Plant", the feasibility of plant site storage was confirmed. The guidelines stated that "for a reactor location with favorable hydrological and geological conditions, it is feasible to use shallow ground burial to dispose certain radwastes at the plant site." Japan has accumulated 460,000 barrels of solid radwastes stored at the reactor sites. The United States had also suggested plant site disposal plans because of increasing disposal costs due to shut-down of three of the four disposal sites in the eastern part of the country.

Final disposal of the solid radwastes and the plant will take place when the nuclear power plant reaches retirement age. Great Britain on the other hand, believes that plant site storage of solid wastes can be considered a form of final disposal.

The long-term process of radwaste disposal may be affected by natural processes or by human activities, which cause radioactive elements to enter the human environment through water infiltration and diffusion. Because of the difficulty in finding an ideal disposal site, man-made screens (e.g., engineering structures) are often used to enhance the isolation effect and the depth of burial is increased to improve safety. The disposed solid wastes must meet the following requirements:

a) there must not be any leakage of liquid or gas; the U.S. Nuclear Regulatory Commission specifies that the amount of free liquid in a waste tank must be less than 1 percent;

b) the container must have sufficient strength to withstand loading, unloading and docking operations; generally, 200-liter steel tanks with wall thickness of at least 1.5 mm are used; Japan specifies that the waste tanks must be able to withstand a load of 5 tons; the United States specifies that the containers must remain corrosion resistant for 20 years and they must be retrievable;

c) the content of super uranium α radiation in the disposed wastes must be strictly controlled.

Solid radwastes of nuclear power plants have much lower screening requirements for the disposal sites than high-radiation, long half-life waste materials. They can be disposed in shallow or medium-depth trenches, and that the heat generated due to decay can be ignored during the disposal period.

V. Suggestions

Disposal of solid radioactive waste of nuclear power plant is an important part of waste management, and directly affects the cost of waste management. During the disposal period, the effect of radiation on the environment and on human beings must be kept "as low as feasible." Disposal of solid radwaste not only is a costly task but also requires the allocation of a large amount of land; therefore, reducing the volume of the waste material is a critical issue of waste management in countries with high developed nuclear power capability as well as in developing countries.

Disposal of solid radioactive waste of nuclear power plant is a complex problem which has technical, economic and social implications. In view of the unique characteristics and far-reaching effects of radioactive wastes, any policy concerning the disposal of radwastes must be proclaimed in the form of national laws or regulations so they will be enforced with sufficient authority. A national radioactive waste management organization should be set up to establish the necessary regulations and standards including radwaste management procedures, waste classification standards, and performance test standards; it should also be responsible for such tasks as mapping the hydrological and geological structures of the earth stratum, studying the mechanism of migration of nuclear elements, selecting appropriate disposal sites for land burial in order to support China's nuclear power industry. Environmental protection is a basic policy of this country; therefore, economic development and urban/rural development must be coordinated with environmental development in terms of planning and implementation in order to reach a balance between economic benefits, social benefits and environmental benefits.

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RECYCLING URANIUM AND PLUTONIUM IN LIGHT WATER REACTOR

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[Text] I. Introduction

The UO_2 elements in a light water reactor (UO_2-LWR) produce approximately 1 percent industrial plutonium after irradiation; most of the plutonium produced are ^{239}Pu and ^{241}Pu, which can be used as fuel for theremal neutron fission. Since the 1950's, western countries in Europe and North America have conducted studies and industrial tests of the recycled utilization of treated nuclear residues of UO_2-LWR. In 1957, the first manufacturing plant of mixed uranium and plutonium oxides (MOX) began operation; in 1963, the first batch of experimental MOX elements were tested with BR_3 irradiation in a reactor. By January 1984, 13 PWR's and 12 BWR's were using MOX elements with a maximum burnout value of 71 GWD/TU[1].

Since the beginning of the LWR industry, recycling U and Pu has been a topic of great interest because of the low utilization rate of LWR fuel and the limited uranium resources. While building FBR is one way to solve this problem, a completely new industrial system which has more stringent requirement than that of LWR must be developed. It is estimated that such a system will not be commercially available until around 2025, and even then its initial economic benefits will not be able to compete with LWR's. Consequently, suggestions have been made to use a MOX-LWR fuel cycle strategy during the LWR and LWR-FBR transition period, i.e., using the retrieved uranium and plutonium from LWR post-processing to make MOX-LWR elements, which can then be reused in LWR's. The author believes this to be an effective approach to improve the fuel utilization LWR, to develop new sources of fuel, and to speed up the accumulation of plutonium for FBR's.

II. Recycling of Uranium and Plutonium in LWR's

1. Recycling of Plutonium

The industrial-grade plutonium (also called primary plutonium) produced from burning UO_2-LWR in LWR's amount to approximately 0.9-1 percent of the total reserves of heavy metals. It contains approximately 1 percent of ^{238}Pu, 58-68 percent of ^{239}Pu, 20-30 percent of ^{240}Pu, 9-10 percent of ^{241}Pu, and 2-6 percent of ^{242}Pu. Primary plutonium can be mixed with depleted uranium, natural uranium and retrieved uranium from post-processing to produce MOX elements, which are reusable in LWR's. Energy will be released from thermal neutron fission of ^{239}Pu, ^{241}Pu and ^{235}U, and the neutrons will again be captured by ^{238}U, ^{238}Pu and ^{240}Pu to produce fissionable plutonium (^{239}Pu, ^{241}Pu). Therefore, by burning recycled elements, there is no intrinsic or quantitative reduction in the fissionable plutonium; in other words, there is no intrinsic change in fissionable contents between secondary plutonium (from MOX elements) and primary plutonium, or between tertiary plutonium and secondary plutonium. This is the basic difference between plutonium and ^{235}U in the UO_2 fuel elements.

Fig. 1 shows the composition of plutonium isotopes at various stages of recycling. After the fifth recycle, the proportions of plutonium isotopes remain unchanged; they do not vary with the number of recycles or with the type of uranium used (natural uranium, depleted uranium, or retrieved uranium from post-processing). The "equilibrium" isotope contents are shown in Table 1[2].

Fig. 2 shows a plot of the variation of fissionable plutonium (Pu_{fis}) as a percentage of the total plutonium with the number of refuelings in the reactor. Initially, Pu_{fis} is about 77 percent of the total plutonium, then it gradually decreases and stabilizes at about 60 percent after 20 refuelings. This "equilibrium composition" of industrial plutonium is totally acceptable for maintaining the production of MOX-LWR elements.

Table 1. Pu Isotope Content After Fifth Recycle of MOX Elements

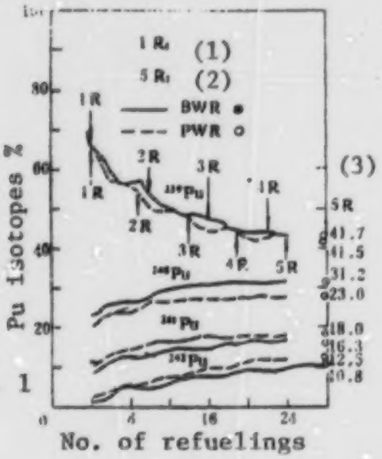

Fig. 1

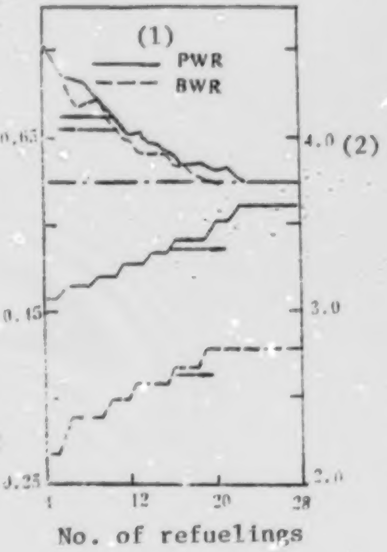

Fig.2

Fig. 1. Composition of Recycled Pu Isotopes in MOX Elements
Key:
(1) 1R: 1st Pu recycle
(2) 5R: 5th Pu recycle
(3) equilibrium composition of Pu isotopes, percent

Fig. 2. Variation of the Proportion of Fissionable Plutonium with Number of Refuelings

Key:
1. use of natural uranium as basic fuel
2. weight of Pu_{fis} in MOX elements

The key considerations for optimum recycling of industrial plutonium are the following: a) the plutonium should be allowed as much time as possible in the reactor to maximize energy production; b) the elements should have an adequate cooling period after being removed from the reactor to ensure disintegration of the short-half-file fission elements in order to reduce the level of irradiation during post-processing; c) the ^{241}Pu should be utilized as much as possible in the reactor before significant decay ($T_{1/2}$=14.4 years) occurs.

Based on the above considerations, the Nuclear Industry Service Co. (NIS) of West Germany suggested that the safest and most economical approach is to have a 2-year period outside the reactor, which includes 1 year of cooling and decay and 1 year of post-processing and element production.

The standard operation for both PWR's and BWR's is to have one refueling per year; in PWR, one-third of the fuel is replaced each time, and in BWR, one-fourth of the fuel is replaced, hence the plutonium recycling periods are respectively 5 years and 6 years. If the life of a reactor is 30 years, then PWR's can be recycled 6 times, BWR's can be recycled 5 times.

The initial proportion of MOX elements in the reactor core is only 3 percent for BWR and 4 percent for PWR. As the number of cycles increases, plutonium production also increases; by the 20th refueling, plutonium consumption and production reach an equilibrium, i.e., the so-called SGR (self-generated recycling) condition, and the proportion of MOX elements becomes approximately 30 percent. Table 2 shows the data of fuel elements for different refuelings; the data do not vary significantly if natural uranium is replaced by depleted uranium or post-processed uranium.

Table 2. Fuel Element Data in a Reactor (Natural Uranium)

表2 反应堆换料元件数据（天然铀基料）

No. of refuel.	$(u+Pu)_{fis}$. Wt%		No. of MOX elements		MOX proportion		Pu_{fis}/Pu_{tot}	
	BWR	PWR	BWR	PWR	BWR	PWR	BWR	PWR
4	2.9	3.8	28	8	3	4	0.75	0.77
8	3.1	3.9	48	12	21	21	0.69	0.71
12	3.3	4.0	56	20	25	27	0.64	0.65
16	3.4	4.1	60	16	28	27	0.62	0.63
20	3.5	4.2	60	20	30	29	0.60	0.61

Based on the "optimum self-generated recycling; mode of operation, plutonium remains inside the reactor for 20 or 18 years of the 30-year reactor life, i.e., more than three-fifths of the time it is producing energy for power generation. However, if the current "delayed plutonium recycling" mode of operation is used, during each cycle it remains outside the reactor for 7 years, plus 1 additional year required for post-processing and element production, i.e., the period of storage and processing outside the reactor is four-fifths of the reactor life. Clearly this is undesirable from the point of view of both economy and safety.

2. Recycling of Uranium

Most of the uranium in the UO_2 elements from a LWR contain ^{238}U and 0.8-0.9 percent of ^{235}U, both of which can be returned to the LWR without much difficulty, but there are also accumulations of ^{232}U, ^{234}U and ^{236}U in the retrieved uranium. Although the ^{232}U content is very low, its strong γ radiation requires special protective measures and the necessary modifications of the industrial flow process [3]. ^{234}U and ^{236}U have strong neutron-absorption capability, hence the presence of ^{234}U and ^{236}U tend to reduce the reactivity of the elements, which can only be compensated by increasing the fuel content.

In terms of ^{234}U and ^{236}U, the first uranium recycle can save 15 percent of natural uranium, but the second recycle can only save 3 percent of natural uranium, hence its economic benefits are limited.

The above discussion shows that from the point of view of cost effectiveness and minimizing processing difficulties, uranium should be recycled only once.

3. Experience of Using MOX Elements in LWR

There are generally two types of MOX modules used in a LWR:

a. "Plutonium Island" Type Modules. In this case, the MOX elements are placed in the center of the reactor core, with enriched UO_2 elements placed around the periphery. This type of module is suitable for BWR's or reactors with large water gaps between the modules.

b. "All Plutonium" Type Modules. This type of module contains only MOX fuel elements and is used primarily in PWR's. In this type of reactor, the effects of guide tubes on flux and peak value coefficients can be corrected by properly selecting the enrichness distribution diagram.

In a typical PWR module, approximately 60 percent of the MOX elements are highly enriched (3.9-4.6 percent fissionable materials), 8 percent are slightly enriched (2.4-2.8 percent fissionable materials), and the remainder are moderately enriched (3.2-3.9 percent fissionable materials).

In a typical BWR module, approximately 50 percent of the MOX elements are highly enriched (3.2-4.6 percent fissionable materials), the other 50 percent are slightly enriched (2.6-3 percent fissionable materials).

With regard to reactor core management, one can follow a procedure similar to that used in UO_2-LWR, i.e., first select the characteristic parameters of the highly enriched elements of the MOX fuel, then determine the number of MOX rods of each module, and finally determine the number of fresh refueling modules.

In order to avoid the formation of power peaks on the boundary between the MOX elements and the UO_2 elements, generally there is a buffer zone in the low-enrichment MOX region.

The MOX element has a melting point 20°C lower than that of the UO_2 element, and its thermal expansion is approximately 1 percent larger; in addition, its γ self-screening effect is better and its heat production is higher. These properties partially compensate for the poor thermal properties of the MOX fuel.

The release of gas from fission products and the expansion of UO_2 or MOX particles are not affected by adding Pu to U, but they are affected by the microcrystalline structure[1].

When the power exceeds 430 W/cm, the plutonium in the fuel rod begins to shift toward the high temperature region; but this is not a problem in MOX-LWR because its linear power level generally is less than 430 W/cm; also, the self-screening effect tends to lower the temperature at the center of the MOX-LWR.

Based on its 20 years of experience, the BN Co. in Belgium found that: 1) MOX fuel contained in a stainless-steel shell performs better than UO_2[4]; 2) there is less mechanical interaction between the MOX fuel plates and the shell than UO_2 fuel elements; 3) MOX has better creep characteristics than UO_2 because of the smaller plate-shell interaction; 4) MOX has slightly lower production of ^{135}Xe than UO_2. ^{135}Xe is an extremely strong neutron absorber, but the effect on reactivity is quite small because MOX has larger neutron absorption cross section than UO_2, thus LWR's using MOX elements operate more steadily; 5) MOX elements cause the moderator temperature coefficient to become more negative, which may result in a slight loss of the reflectivity margin when the reactor is shut down [5]; 6) because of the more negative Doppler coefficient and moderator temperature coefficient of the MOX elements, the power of MOX-LWR decreases more slowly than UO_2-LWR; this leads to better self-screening and better self-modulation; 7) the γ scan spectrum of discarded elements showed evidence of good power distribution when the burnout of "plutonium island" elements is very high [6].

A study done by CEA of France showed that in a mixed loading of MOX-UO_2 elements, the neutron flux is discontinuous, therefore, the reactor physics method of calculation should be modified [7].

The research done by Sweden showed that the slow neutrons emitted by plutonium isotopes are two-thirds less than those emitted by uranium isotopes. Therefore, MOX elements will respond faster to a change in reactivity than UO_2 elements. This would have an undesirable effect in case of an accident such as ejection of control rod in PWR or dropping of control rod in BWR, but because of the large negative Doppler coefficient, the accident will terminate very quickly [8].

Fig. 3 presents a reactivity equilibrium diagram of PWR proposed by the West German Power Plant Union (KWU); it shows a comparison of reactivity in a PWR when different fuel elements are used [5].

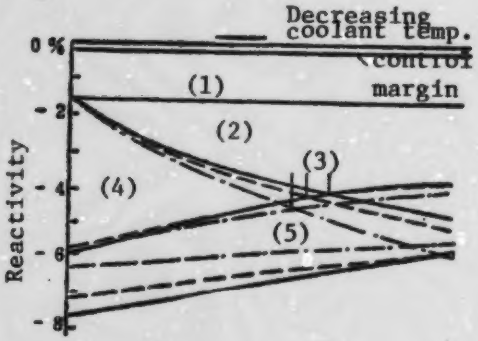

Fig. 3 Reactivity Equilibrium Diagram for Different Fuel Modules in a PWR

Key:
- (1) emergency shut-down Doppler effect
- (2) reactivity due to decreasing coolant temperature
- (3) returning to critical state
- (4) reactor shut-down margin
- (5) jammed control rod

III. Fuel Cycle

The fuel cycle is generally divided into the front and rear segments. The front segment includes mining, mineral processing, enrichment and element fabrication; the rear segment includes temporary storage of nuclear residues, post-processing, conversion, waste treatment and permanent disposal. The recycling of U and Pu in LWR reduces the load on mining, processing and enrichment of natural uranium, but it poses some new problems for element fabrication, post-processing and conversion. This section briefly discusses the difference between MOX and UO_2 and the resulting effect on fuel cycle industrial units.

1. Post-Processing

The main differences between MOX and UO_2 elements with the same burnout and the same cooling period are: a) MOX elements have different levels of fission products, approximately 30-70 percent higher in ^{106}Ru, ^{106}Rh, ^{85}Kr and ^{129}I, and approximately 10 percent lower in ^{95}Zr-^{95}Nb; b) MOX elements have different levels of the actinium series--3 percent less in U, 1-3 times more in Pu, Am and Cm; c) there are also differences in physical-chemical properties such as thermal property, heat-conductivity, solubility, melting point, and density. These differences have the following effects on post-processing:

(1) Segment Processing. There are no major changes in such procedures as transportation, fuel removal, storage, disassembly of modules and cutting of fuel rods between MOX-LWR elements and UO_2-LWR elements.

The dissolving of MOX waste elements is a major problem. If the conventional method of mechanically mixing the UO_2 and PuO_2 powder is used, there will be a large particles which are difficult to dissolve even in boiling, high-concentration HNO_3 solution. The best way to solve this problem is to choose a fabrication process for MOX such that the U and Pu atoms can be interchanged in the lattice. Research showed that the following process is quite satisfactory: a) grinding the UO_2 and PuO_2 particles to a highly refined powder (less than 0.5) and carefully mixing them; b) applying the conversion process to the mixture.

(2) Extraction. The Pu content in MOX is 2-3 times higher than that in UO_2, but since the distribution ratio of Pu(IV) in the 30 percent TBP-OK is smaller, appropriate measures must be taken if the level of Pu loss in the extracted liquid waste is to be maintained at the same level of U loss in processing UO_2 fuel. If the number of extraction stages is increased or the extraction stage is lengthened, then high-acid (>3M) operation should be used between the extraction stage and the washing stage instead of $2MHNO_3$, so that Pu(IV) can be extracted into the organic phase. High-acid operation will reduce the cleaning action for Zr/Nb, but will enhance the cleaning of Ru/Rh; hence it is compatible with the variation in fission product spectrum (Zr, Nb less than 10 percent, Ru, Rh greater than 70 percent).

The separation of U and Pu can be accomplished by existing reduction techniques, but most of these techniques can be improved, or a combination of two different techniques can be used [9].

The same purification process is used for plutonium as in UO_2-LWR, i.e., the electrolysis reduction process. But because of the 2-3 times increase in plutonium content, the design of post-processing plant for UO_2-LWR should be modified to avoid adverse effect on its processing capability.

In the purification of uranium, it is required that the total α specific radiation of the uranium product be less than 15,000 dpm/gU. Because of the increased super uranium content in the wastes of MOX-LWR the purification process must be strengthened to improve its cleaning ability.

(3) The Three Wastes of Post-Processing. Sixty to seventy percent of the total tritium is collected on the shell of the MOX-LWR elements, which is 30 percent more than UO_2-LWR. The structural components and the head and tail blocks of the fuel modules do not differ from those of UO_2-LWR. The amount and radiation level of the dissolved residues are approximately the same as those of UO_2-LWR. The concentration of fission products in the high-radiation liquid waste is approximately 20 percent higher than that of UO_2-LWR, and the amount of heat released is also higher; this will have an effect on the heat released is also higher; this will have an effect on the heat dissipation and cooling desing of the HAWC container. When glass solidifies, its envelope volume must be reduced. Because of the large plutonium content, the amount of medium and low radiation liquid waste will increase, and the amount of plutonium loss in the liquid waste is 1 percent less than that of UO_2-LWR. The amount of escaped volatile nuclear elements is also higher than that of UO_2-LWR, specifically, ^3H is 30 percent higher. ^{85}Kr is 40 percent higher, and ^{129}I is 30 percent higher. There is an obvious drop in solvent effectiveness due to increases in α dosage and in β/γ dosage; therefore, the solvent processing technique and equipment must be chosen with care.

(4) Feasibility of Post-Processing. The above analysis yields the following conclusions: a) there is no basic difference between MOX-LWR and UO_2-LWR post-processing except for quantitative variations; b) the post-processing of MOX-LWR waste elements can be accomplished by making simple modifications to the existing methods for processing UO_LWR.

2. Conversion

The process of transforming $Pu(NO_3)_4$ and $UO_2(NO_3)_2$ obtained from post-processing or a mixture of the two into PuO_2, UO_2 or $(Pu,U)O_2$ is referred to as the conversion process. It is an essential link between post-processing and element refabrication. There are two approaches used to produce $(Pu,U)O_2$: "conversion followed by mixing" and "mixing followed by conversion".

(1) "Conversion Followed by Mixing". This approach involves first converting uranium and plutonium into MO_2, then mixing them; it has been in use for almost 30 years. In the early days, the MO_2 particles were large in size and poor in uniformity; they were difficult to dissolve even in boiling high-concentration HNO_3 solution. Only by adding HF to HNO_3 was it possible to reduce the insoluble residues to a level of less than 1 percent, but the introduction of HF leads to severe corrosion of the equipment. Subsequently, it was discovered that the above difficulties can be overcome by pulverizing the MO_2 particles to a size smaller than 0.5μ so they are in a free flowing state.

(2) "Mixing Followed by Conversion". This approach involves first mixing $Pu(NO_3)_4$ and $UO_2(NO_3)_2$, then converting the mixed solution into $(Pu,U)O_2$. This method provides a direct and simple way to dissolve MOX. Currently, three such techniques are being studied extensively: the sol-gel technique, the direct denitration technique, and the joint precipitation technique.

(i) The sol-gel technique. Based on the requirement of reactor core design, the $Pu(NO_3)_4$ and the $UO_2(NO_3)_2$, solutions are mixed according to a prescribed proportion and evaporated in vacuum; then, by adding a certain amount of reagent to the mixture and passing the mixture through a pulse jet nozzle, "gel balls" are formed. Finally, they are washed with NH_4OH, dried, inspected, baked, and sintered to produce the raw material for element fabrication.

(ii) The direct denitration technique. In this case, $(U,Pu)NO_3$ is converted directly into $(U,Pu)O_2$ in either a vulcanization bed or a microwave oven. Both techniques share the following common features:

a) the mixed U. Pu solution can be converted directly; b) the conversion process is simple; c) the product requires further pulverization; d) very little liquid wastes are produced. But the vulcanization technique has a number of advantages over the microwave technique [12, 13].

(iii) the Joint precipitation technique. This is an advanced technique for producing MOX which uses NH_4OH as the precipitation system. The Pu(IV) oxalate system is ideal for plutonium conversion, but it is not suited for joint preciptiation because the oxalate of Pu precipitates faster than that of U, thereby causing changes in the MOX composition. The Alkem Co. of West Germany developed the AUPuC process which uses NH_4OH to produce a solid mixture is then filtered or directly sintered with the slush in a vulcanization bed.

The precipitated MOX powder, like the product from microwave denitration, are small in size (0.67μ) and have large surface ration (9.5 m^2/g); they are also highly reactive and can readily be made into tablets. The precipitation technique produces about twice as much ammonium nitrate waste water as the sol-gel technique. The joint precipitation technique has been used by some countries, and each batch produces approximately 1-2 tons of fuel [1].

3. Element Fabrication

Most of today's large-scale MOX-LWR element fabrication processes are based on the "conversion followed by Mixing" method. The procedures are similar to those used for UO_2 element fabrication, and the equipment are essentially the same.

In recent years, the United States had established a "Consolidated Fuel Post-Processing Plan' (CFRP) under which the Oak Hill Laboratory, the Hanford Laboratory and the Pacific Northwest Laboratory are jointly studying the "gel ball-tablet" technique, and have already produced high-quality elements with high density (90-96% TD), good microcrystalline structure and high mechanical strength.

There are other techniques in which the gel balls from the sol-gel technique are sintered and inserted into the fuel tubes through vibration to form the element rods. Practical experience with this technique is still quite limited; the United States plans to use it as the technique for advanced fuel fabrication in the future.

The large amount of plutonium required for the fabrication of MOX elements produces some special problems; specifically, they are: a) the problem of self-generated heat of Pu; b) the problem of dissolving of Pu; c) the problem of hydrogen content; and d) the problem of contamination of plutonium dust[11]. These problems can be overcome by choosing the appropriate procedures, using the proper equipment and materials, and through intelligent design and management.

IV. Safety Analysis

Safety analysis is a complicated issue which covers a wide range of different areas. The U.S. Government and the European Common Entity had organized a special group of scientists who had devoted a considerable amount of effort in carrying out the safety analyses of recycling U and Pu in LWR and publishing an extensive report.

1. Main Conclusions of the European Common Entity

The European Common Entity made the assumption that by the end of this century, the total nuclear power capacity of the Entity will be 150 GWe, and the primary power source will be LWR. It is estimated that at that time, 10 tons of fissionable plutonium will be recycled each year, producing 400 tons of MOX fuel, which is equivalent to about 10 percent of the LWR fuel. These MOX will be recycled in 50 of the 150 power plants; they account for 30 percent of the fuel used in these reactors, which will be operating in a self-sustaining mode, i.e., they produce all the plutonium being recycled. Based on this scenario, the group of European scientists reached the following conclusions: a) with regard to public radiation level, it is 51 personsievert with recycling, 70 person-sievert without recycling, and the natural background is 400,000 person-sievert, thus the level with recycling is less than the level without recycling which is less than the natural background; b) with regard to individual radiation level for a professional worker, there is a 10 percent with recycling, but the professional group radiation level is reduced by 10 person-sievert per 10 ton of plutonium; c) in any case, the radiation dosage is far below the allowable value specified in the safety standards; d) with regard to non-radioactive environmental effects, there is no significant difference between the recycling case and the non-recycling case in terms of land use requirement, transportation, non-radioactive wastes and heat release.

2. Main Conclusions of the U.S. Government

After several years of detailed analyses and calculations, the U.S. NRC issued a final environmental report which addresses the issues of health protection, safety, and environmental effects. In particular, they compared five different fuel cycling modes: mode 1: immediate post-processing and U recycling, delayed Pu recycling; mode 2: delayed post-processing followed by U,Pu recycling; mode 3: immediate U,Pu recycling; mode 4: U recycling, but no Pu recycling; mode 5: no U or Pu recycling.

The basic assumptions for these estimates are as follows: a) time period: 1975-2000; b) nuclear power capacity: $5X10^{11}$ W by the year 2000; c) total power output: $3.5X10^{13}$ KW·h.

The key results of the report are summarized in Tables 3, 4 and 5. It is seen that: a) the effect of U,Pu recycling in the U.S. on public radiation dosage and on the cancer death rate is only 1 percent of the natural background; b) the differences in the effect on either public radiation dosage or cancer death rate between the different modes are far below the fluctuation levels of the natural background.

Table 3. Effect of U, Pu Recycling on Human Radiation Dosage in the United States

Key:
1. rad dosage, 10^6 person rem
2. mode
3. natural background
4. U.S.
5. professional workers
6. outside residents
7. entire population
8. foreign countries
9. whole world (including U.S.)

Table 4. Effect of U, Pu Recycling on Human Health in the United States

Key:
1. effect on health
2. mode
3. natural background
4. cancer death rate
5. general public in U.S.
6. whole world (including U.S.)
7. genetic defects

Table 5. Effect of U, Pu Recycling on the U.S. Environment*

Key:
(1) other radioactive elements
(2) residue from ore dressing
(3) super uranium solid
(4) high-radiation solid waste

表5 美国U、P$_u$返循环工业对环境的影响*

Environmental Factors		Mode 1.2.3	Mode 5	Mode 6
Resource utilization	land area, acres	3.4×10^4	4.0×10^4	5.0×10^4
	water, gallons	1.2×10^{14}	1.3×10^{14}	1.3×10^{14}
	dissipated heat, BTU	2.9×10^{17}	2.9×10^{17}	2.9×10^{17}
	coal, tons**	8.9×10^8	9.0×10^8	9.0×10^8
	gas, 10^5 BTU	1.0×10^{10}	1.2×10^{10}	1.3×10^{10}
	oil, gallons	2.0×10^{10}	2.0×10^{10}	1.9×10^{10}
	Elec. GW·Y	3.8×10^2	3.8×10^2	3.8×10^2
Factory discharge	^{222}Rn	2.3×10^7	2.5×10^7	2.8×10^7
	^{220}Rh	1.1×10^1	1.3×10^1	1.4×10^1
	U	8.7×10^2	1.0×10^3	1.1×10^3
	^{230}Th	3.2×10^1	3.6×10^1	4.2×10^{10}
	Pu(α)	4.6	3.0	2.3×10^{-3}
	Pu(β)	1.2×10^2	7.4×10^1	3.0×10^{-2}
	TrPu	1.1×10^1	5.3	9.0×10^{-4}
	^{3}H	6.5×10^7	6.4×10^7	4.7×10^6
	^{14}C	1.2×10^3	1.2×10^3	4.3×10^4
	^{85}Kr	1.3×10^9	1.3×10^9	2.6×10^6
	^{90}Sr	1.8×10^1	1.8×10^1	2.5×10^{-3}
	^{99}Tc	4.5×10^2	5.3×10^2	—
	^{129}I	1.1×10^2	1.1×10^2	—
	^{131}I	3.4×10^3	3.3×10^3	8.0×10^2
	(1)	5.3×10^7	5.4×10^7	5.4×10^7
Factory waste (M³)	(2)	5.9×10^8	6.9×10^8	7.8×10^8
	(3)	1.5×10^5	1.3×10^5	—
	(4)	6.5×10^3	6.5×10^3	5.5×10^4

* These effects include: mining, ore dressing, UF$_3$ conversion, U element fabrication, MOX element fabrication, reactors, post-processing, transportation, waste management, and waste fuel storage.

** Includes the coal used by fuel recyling plants and by coal-fired power plants which provide 2/3 of the electricity.

V. Analysis of Social and Economic Benefits

The economic benefits of recycling U. Pu in LWR are quite obvious; even more apparent are the social benefits such as conservation of resources and safety considerations.

1. Savings in Natural Uranium and Separation Power

Because of the different assumptions used by different countries, the estimated amount of savings vary from one country to another. Fig. 6 shows that approximately 35-40 percent of natural uranium can be saved by recycling U, Pu in LWR. For a 1300 MWe PWR, this is equivalent to 80 tons of natural uranium each year.

2. A Good Way to Solve the Pu Storage Problem

The purpose of recycling Pu in LWR is to replenish the depleted uranium; but once it reaches a certain level, power generation can be maintained by the self-generated plutonium, and the plutonium regeneration process will become self-sustaining. This form of "energy-producing storage" is clearly more desirable than the conventional form of storage. The cost savings realized by a 1000 MWe LWR by using recycled Pu over PuO$_2$ storage are as follows: approximately (1.9-4.8) x10^6 dollars per year for 5-year storage; approximately (3.1-6.2)x10^6 dollars per year for 15-year storage (based on 1983 U.S. dollar). These data show that it is uneconomical to store Pu for 20-40 years until FBR becomes operational.

Table 6. Savings in Natural Uranium Due to Pu Recycling

表6 返循环节约天然铀数值

		P$_u$ recyc.	U recyc.	P$_u$+U recyc.
	(1) (INFCE) (1980)	20%	20%	35—40%
Ger.	(BMFT) (1981.10.)	20—30%	15—20%(一次)	40%
U.S.	(NRC) (1976.9)	—	10%	22%
	(ERDA) (1976.12)	—	—	26%
Japan	[14](NAIG) (1982)	—	17—19%	—
France	(CEA—CEN) (1982)	—	18%	—
Belgium	(BN)[11](1983)	—	—	~35%
(2)	(U.R.G)(1977)	—	—	30%

Key:

(1) International Nuclear Fuel Cycle Evaluation
(2) United Post-Processing Company

3. Moderate Reduction in Fuel Cost

It is INFCE's opinion that from a narrow economic view point, the economic benefits of recycling U, Pu in LWR are quite limited, but if one considers the depleting resources, rising uranium prices, and high cost of developing FBR's, recycling U and Pu will become very attractive.

The conclusion of NRC is: The cost saving of recycling U, Pu over the single-pass mode of operation is about 8.1 percent.

4. Becoming Self Reliant in Nuclear Fuel and Protecting the Fuel Supply

Recycling U, Pu in LWR also helps realizing the goal of becoming self-reliant in nuclear fuel and protecting the fuel supply. This is significant for countries which are developing their LWR industry but have very limited uranium resources.

VI. A Quick Review of China's Strategy on LWR Fuel Cycle

According to China's nuclear power development plan, the near-term efforts will concentrate on building million KW-class PWR's and on developing FBR's. One of the important issues that affects the operation and economic benefits of nuclear power plants is to decide on a fuel cycle strategy. In the following sections, we shall present an analysis of this issue based on China's current conditions.

1. Three Different Modes of Fuel Cycle

During the several decades when LWR's transition to FBR's, there are three possible modes of processing UO_2-LWR nuclear wastes (Fig. 4). Their advantages and disadvantages are summarized below:

Mode 1: a) After several decades of storing post-processed Pu, all the ^{241}Pu, which is 1/7-1/8 of the fissionable plutonium, will become ^{241}Am and lost; b) Because of the strong α, γ, n radiation of ^{241}Am, special production lines must be built to meet super-plutonium requirements, and costly purification procedures will be required for fabricating FBR elements.

Mode 2: a) One seventh to one eighth of the fissionable plutonium will be lost; b) The problems of storage and heat release, corrosion, monitoring, damage and retrieval must be solved.

Mode 3: a) There is basically no loss in fissionable plutonium; b) A 35-40 percent saving in natural uranium and separation power can be achieved; c) The cost of fuel cycle is reduced by 10 percent; d) It contributes toward self-reliance in nuclear fuel and protection of fuel supply; e) The energy of Pu can be fully utilized, i.e., 3/5 of the time before FBR becomes operational, it is used to generate electricity.

The above analysis shows that mode 3 provides the best social and economic benefits.

Fig 4. Three Possible Modes of LWR Fuel Cycle

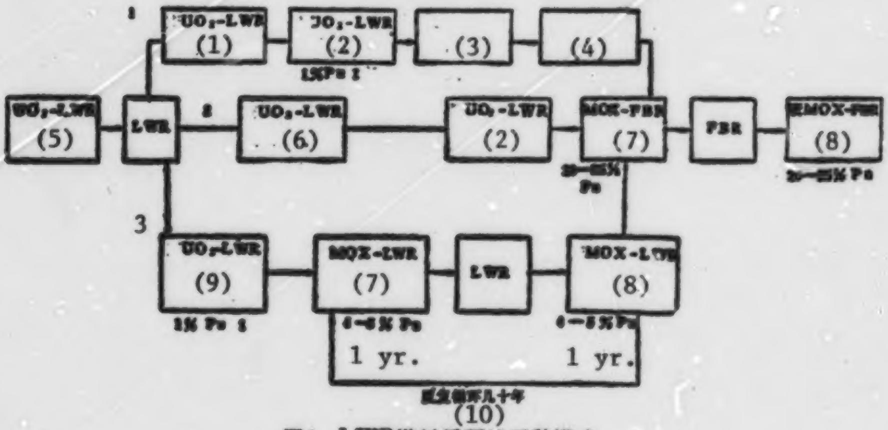

图4 LWR燃料循环的三种模式

Key:

1. storage of waste UO_2-LWR for 5 years
2. post-processing of waste UO_2-LWR
3. storage of Pu for several decades
4. repurification
5. fabrication of UO_2-LWR elements
6. storage of UO_2-LWR for several decades
7. fabrication of MOX-FBR elements
8. post-processing of waste MOX-FBR
9. post-processing of waste UO_2-LWR (cooling for 1 year)
10. recycling for several decades

2. Current Status of China's Nuclear Fuel Industry

(1) Nuclear Resources. China's proven resources that have industrial values can provide enough fuel for military use and for the operation of 15 million-KW PWR's for 30 years [15]. By around 2020, the uranium resources will be mostly depleted [16, 17]. Also, the average grade of China's uranium ore is quite low and the costs of mining and separation power are high.

(2) Post Processing Industry. China's post-processing industry has almost 20 years of operating experience, and has a team of well-trained researchers, designers and operators, who had laid a solid foundation for LWR post-processing.

(3) Plutonium Industry. China has accumulated considerable experience in the operation of the plutonium industry to be able to develop an industry of MOX element fabrication.

(4) Economic Conditions. China is still an economically underdeveloped country with per capita output of less than 400 dollars per year. Therefore, it is not possible for China to spend a great deal of money in this century to develop fast reactors or to devote its resources to large-scale development of PWR nuclear power plants. Under these circumstances, U and Pu recycling is attractive because only a moderate of money is needed for the design, fabrication and inspection of MOX-LWR elements.

Based on the above discussions, the author believes that recycling U and Pu in LWR is consistent with China's current resource, economic and industrial conditions, and is consistent with the guidelines of "becoming self-reliant in nuclear fuel, reducing the cost of power generation"; it is also feasible from technical and safety considerations and provides stimulant for the development of FBR's. Therefore, it is recommended that recycling U and Pu be adopted as China's fuel cycle strategy.

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SINGLE BOARD DIGITAL CONTROL SYSTEM FOR EPITAXIAL REACTOR

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86 pp 19-24

[Article by Liang Renqiu [2733 0117 7264] and Huang Shengjun [7806 0524 6511] of Qinghua University: "Single Board Direct Digital Control System for Epitaxial Reactor"; manuscript submitted in January 1985, revised manuscript received in August 1985]

[Text] Abstract: This paper discusses the structure and characteristics of a single board digital control system for a vapor phase epitaxial reactor, the mathematical model established, and the two designs for the digital controller. The control software and the operation of the system are also described. The system has already been successfully placed on a production line.

1. Introduction

In manufacturing modern integrated semiconductor circuits, very stringent requirements are imposed on the thickness and dopant levels in the epitaxial layer on silicon. For this reason, the temperature of the silicon wafer in the oven, the gas flow rate and the processing time must be accurately controlled.[1] In other countries, small computers are being used for direct digital control.[2] In 1983, China completed the development of direct digital control by using microprocessors in the laboratory. However, it is too costly. At the end of 1983, Qinghua University and Beijing Electronic Tube Plant jointly developed a direct digital control system for a Chinese made epitaxial reactor, resulting in a single board control system with some special features. The system uses a Model TP-801 single board computer for direct digital control and program control of a vapor phase silicon epitaxial furnace. It was brought on line in late 1984 and has been working satisfactorily to date.

2. Structure and Characteristics of the System

The structure of the system is shown in Figure 1. The single board computer sends out the digital temperature signal. Through the 8 bit D/A converter (DAC), the optoelectronic coupling (isolation) circuit and the switch S, the three phase ac voltage regulating thyristor device can be controlled. The ac output of this device is stepped up, rectified and filtered, and then sent to the LC oscillator which generates a 400 kHz current to heat the epitaxial furnace. The voltage regulator, step-up transformer, rectifier and filter also form a local negative feedback system to regulate the silicon wafer temperature. The wafer temperature is measured and displayed by a non-contact optoelectronic infrared thermometer.

The system employs seven isolated switching ports. Sampling cycles and processing periods are generated by using 4 channels of the Z80-CTC and some software program. In addition to the 6 and 4 digit displays on the single board computer and thermometer, respectively, the system has a 11 digit display where 4 digits are used to show the processing time, 3 for HCl flow rate and 2 each for PCl3 and SiCl4 flow rates. The PIO on the computer is used for displaying various epitaxial steps and "flow" platterns for the gases, as well as for an optical-acoustic alarm.

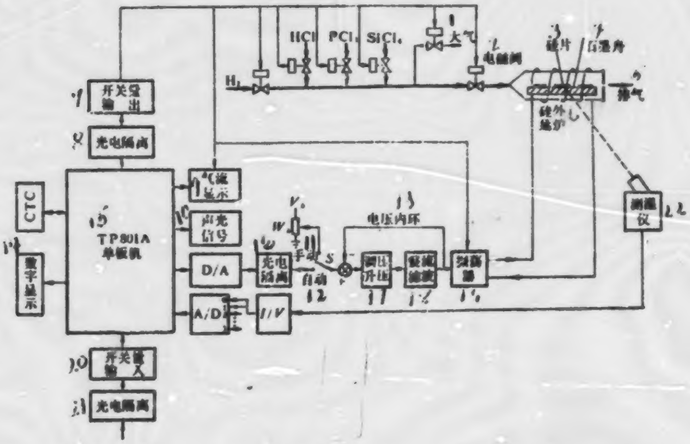
HCl
PCl₃
SiCl₄
1 大气
2 电磁阀
3 硅片
4 石墨舟
H₂
5 排气
6 硅外延炉
7 开关量输出
8 光电隔离
CTC
15 TP801A 单板机
14 数字显示
9 气流显示
10 声光信号
D/A
A/D
I/V
16 光电隔离
V₀
W
11 手动
12 自动
S
13 电压内环
17 调压升压
18 整流滤波
19 振荡器
22 测温仪
20 开关量输入
21 光电隔离

Figure 1. Structure of Single Board Direct Digital Control System for Vapor Phase Epitaxial Reactor.

Key:

1. Atmosphere
2. Electromagnetic valve
3. Silicon wafer
4. Graphite boat
5. Exhaust
6. Silicon epitaxial furnace
7. Switching parameter output
8. Optoelectronic isolation
9. Flow display
10. Photo-acoustic signal
11. Manual
12. Automatic
13. Voltage loop
14. Digital display
15. Single board computer
16. Optoelectronic isolation
17. Voltage regulator
18. Rectifier and filter
19. Oscillator
20. Switching parameter input
21. Optoelectronic insulation
22. Temperature monitor

Based on Figure 1 we know that the system is a serial direct digital control system consisting of an analog inner loop and a digital outer loop. It is also a program controlled system for various valves. The system has the following special features: 1) In the neighborhood of 1200°C, the temperature control error is less than ± 4°C. 2) Through man-machine dialogue, major epitaxial parameters can be changed at any time to quickly change over to another type of integrated circuit with ease. 3) Silicon wafer temperature, processing durations and gas flow rates are digitally displayed. If the temperature exceeds its limits or the computer is out of order, an optical-acoustic alarm will be activated so that the system can immediately be switched to manual operation. 4) A method involving the use of a bias and program switching is used to realize the high resolution conversion of temperature signal by a low resolution ADC. 5) The program and some data are loaded in an EPROM; 6) Effective measures such as low pass filtering, isolation, de-coupling, shielding and grounding are used to resist interference. Even in the presence of intense interference by the 400 kHz high frequency power supply and spatial electric field, it can operate reliably on the production line. 7) The equipment and instruments used, including the DC-8B microcomputer control device, temperature probe and high frequency power supply, are made in China. The costs are very low.

3. Establishment of the Mathematical Model

In order to find a transfer for the epitaxial furnace including the inner voltage loop, the LC oscillator and the temperature measuring device, we created a rising curve digital measurement system as shown in Figure 2. Near the actual operating temperature, the single board computer sends output with sudden increment or decrement. The relevant rising curve is automatically stored in internal memory and then printed out. Based on these data, a curve can be plotted and the transfer function can be determined.[3] Through plotting and computation, the time constant τ_1 is 45 seconds, the magnification factor K_1 is 3.44, and the pure time lag θ is 1 second. The transfer function can be written as:

$$\begin{aligned} W_{p1}(S) &= K_1' e^{-\theta S}/(\tau_1 S+1) \\ &= 3.44 e^{-S}/(45S+1) \qquad (1) \end{aligned}$$

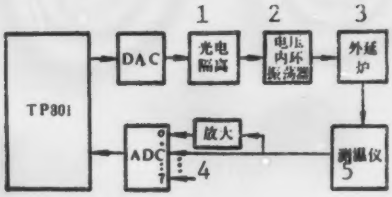

Figure 2. Digital Measurement System for the Rising Curve

Key:
1. Optoelectronic isolation
2. Voltage loop oscillator
3. Epitaxial furnace
4. Amplifier
5. Temperature monitor

Because the pure time lag is very small compared to the time constant, the system can be treated as a first order inertia system whose transfer function is:

$$W_{p1}(S)=3.44/(45S+1) \qquad (2)$$

This is the transfer function measured in channel 1 of the ADC. Because the 0 channel used for PID modulation is also used to amplify the analog voltage to be converted by a factor of 4.4 to raise its resolution, the transfer function for this temperature control channel should be:

$$W_{p0}(S)=K_1'\times 4.4/(\tau_1+1)=K_1/(\tau_1 S+1)\approx 15/(45S+1) \qquad (3)$$

After considering the transfer function $W_h(S)$ of the zero order holder which is formed by the DCA input register, the final complete transfer function is:

$$\begin{aligned} W_p(S) &= W_{p0}(S)\cdot W_h(S)=[K_1/(\tau_1 S+1)]\cdot[(1-e^{-TS})/S] \\ &= 15(1-e^{-TS})/S(45S+1) \qquad (4) \end{aligned}$$

T is the sampling cycle in the above equation which is chosen to be 1 second. By performing z transformation for equation (4), the pulse transfer function is obtained.

$$W_p(z)=0.3297z^{-1}/(1-0.978z^{-1}) \qquad (5)$$

If conditions permit, we may use the least square method to conduct off-line recognition to directly determine this pulse transfer function.

4. Digital Controller

Based on the requirement in the epitaxial process, the silicon wafer temperature to be controlled by the system should follow the pattern shown in Figure 3. From room temperature T_0 to point a, the system uses an open loop control to raise the temperature at a slope Δ_1 without measuring temperature. From point a to b, the temperature is checked in an open loop control to increase the temperature at a slope Δ_2. Once the silicon wafer temperature is raised to b (temperature T_R), the system enters the PID modulating mode. It automatically switches channel of the ADC to channel 0 and begins PDI closed loop control. From point c to d, it is the constant temperature segment. It is required to be under PID control to ensure the required accuracy in silicon wafer temperature. After the epitaxial procedure is completed, i.e. from point d to e and e to f, open loop control is used to lower the temperature at slopes Δ_3 and Δ_4, respectively.

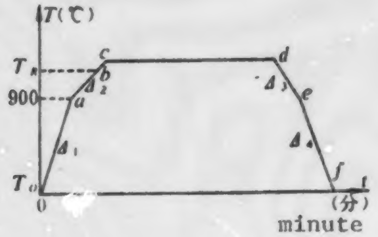

Figure 3

There are many ways to design the digital temperature controller in segments bc and cd. Because the system is a definitive single input/single output system, it is all right to use the conventional PID method or some practical engineering algorithm with pure lag. For instance, it is possible to use the following direct digital design method.[4,5]

Figure 4 shows the block diagram of the structure of the system. D(z) is the pulse transfer function of the digital controller. Y(z), U(z), E(z) and C(z) are the z transformation of the system output, given value, control error, and digital controller output, respectively. The closed-loop transfer function of the system is:

$$W_c(z)=D(z)W_p(z)/[1+D(z)W_p(z)] \tag{6}$$

From equation (6) we can obtain the pulse transfer function of the digital controller:

$$D(z)=C(z)/E(z)=W_c(z)/W_p(z)[1-W_c(z)] \tag{7}$$

When the static error of the system is 0, we get the following based on the final value theorem:

$$e(\infty)=\mathop{\mathrm{Lim}}_{z\to 1}\{(1-z^{-1})U(z)[1-W_c(z)]\}=0 \tag{8}$$

Let us assume that the input is a unit step function. The unit step pulse function is:

$$U(z)=1/(1-z^{-1}) \tag{9}$$

To make equation (8) equal to 0, the closed loop pulse transfer function of the system should be $W_c(z) = z^{-1}$. By substituting equations (5) and (9) into (7), the specific pulse transfer function of the digital controller is:

$$D(z)=C(z)/E(z)=W_c(z)/W_p(z)[1-W_c(z)]=(3.033-2.966z^{-1})/(1-z^{-1}) \tag{10}$$

This is a PI modulated model. By multiplying equation (10) to C(z)/E(z) and then performing an inverse z transformation, we get the following difference equation or control scheme which is suited to be computed on a computer.

$$c(k)=c(k-1)+3.033e(k)-2.966e(k-1) \tag{11}$$

This is the theoretical design. We mentioned that the closed loop pulse transfer function of the system is $W_c(z) = z^{-1}$. This indicates that the output of the system can vary with respect to the previous input within the same beat (one sampling cycle). Due to the saturation characteristics of the loops in the system, this is not attainable. The parameters in equation (11) must be corrected accordingly in testing.

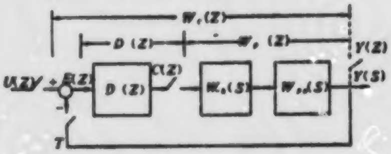

Figure 4. Block Diagram of the Structure

As a result of testing, the parameter expressed in equation (11) were found to be usable. The temperature variation is less than ± 4°C and the transition time is under 45 seconds. The parameter was modified to include b2e(k-2) term and point differentiation was introduced; i.e. to adopt the following PID modulation model:

$$c(k)=c(k-1)+b_0e(k)-b_1e(k-1)+b_2e(k-2) \tag{12}$$

The performance is thus improved. Tests showed that there was no overshoot when temperature was raised at a given slope. The static temperature variation was less than ± 4°C and the transition time was under 35 seconds. When a 17°C temperature disturbance was introduced abruptly, the recovery time was under 25 seconds. These specifications can satisfy all technical requirements.

The Dahlin algorithm was also used to design the digital controller[6,7]. Based on this method, when zeroth order register is not taken into account, the transfer function is:

$$W_p(S)=K_1e^{-\theta S}/(\tau_1S+1) \tag{13}$$

The design is to find an appropriate digital controller D(z) for closed loop control. The closed loop transfer function is an inertia loop and a pure lag loop in series. In addition, the pure lag time is that of the subject, i.e.

$$W_c(S)=e^{-\theta S}/(\tau S+1) \tag{14}$$

Let the lag time 0 be N times the sampling cycle T, where N is a positive integer, i.e. 0 = NT. The pulse transfer function of the closed loop system is

$$\begin{aligned} W_c(z)&=\mathscr{Z}[W_c(S)\cdot(1-e^{-TS})/S] \\ &=\mathscr{Z}\{[e^{-NTS}/(\tau S+1)]\cdot[(1-e^{-TS})/S]\} \\ &=(1-e^{-T/\tau})z^{-N-1}/(1-e^{-T/\tau}z^{-1}) \end{aligned} \tag{15}$$

The pulse transfer function after taking the zero order register into account is:

$$W_p(z)=\mathscr{Z}\{[(1-e^{-Ts})/S]\cdot[K_1e^{-NTs}/(\tau_1S+1)]\}$$
$$=K_1z^{-N-1}(1-e^{-T}/\tau_1)/(1-e^{-T/\tau_1}z^{-1}) \qquad (16)$$

By substituting equations (15) and (16) into equation (7), the pulse transfer function of the digital controller can be obtained:

$$D(z)=\frac{C(z)}{E(z)}=\frac{W_e(z)}{W_p(z)[1-W_e(z)]}$$
$$=\frac{(1-e^{-T/\tau})(1-e^{-T/\tau_1}z^{-1})}{K_1(1-e^{-T/\tau_1})[1-e^{-T/\tau}z^{-1}-(1-e^{-T/\tau})z^{-N-1}}$$
$$=\frac{(1-e^{-T/\tau})/K_1(1-e^{-T/\tau_1})-(1-e^{-T/\tau})e^{-T/\tau_1}z^{-1}/K_1(1-e^{-T/\tau_1})}{1-e^{-T/\tau}z^{-1}-(1-e^{-T/\tau})z^{-N-1}}$$
$$=\frac{b_0-b_1z^{-1}}{1-a_1z^{-1}-a_2z^{-N-1}} \qquad (17)$$

By cross-multiplying equation (17) with C(z)/E(z), we get

$$C(z)(1-a_1z^{-1}-a_2z^{-N-1})=(b_0-b_1z^{-1})E(z)$$

By doing a inverse z-transformation, the algorithm of the digital controller can be obtained.

$$c(k)=a_1c(k-1)+a_2c(k-N-1)+b_0e(k)-b_1e(k-1) \qquad (18)$$

where $a_1=e^{-T/\tau}$, $a_2=1-e^{-T/\tau}$, $b_0=(1-e^{-T/\tau})/K_1(1-e^{-T/\tau_1})$, $b_1=b_0e^{-T/\tau_1}$

(Based on equation (17).)

When this algorithm was used, some parameters were slightly modified; i.e. K_1=13, τ_1=48 sec, T=1 sec, 0=1 sec, N=0/T=1, $\tau=\tau_1/3$=16 sec. Based on equation (18), the specific control algorithm of the system can be obtained:

$$c(k)=0.9394c(k-1)+0.0606c(k-2)+0.2245e(k)-0.2199e(k-1) \qquad (19)$$

The result of this algorithm showed that no temperature overshoot at a given slope. The static temperature variation was less than ± 4°C. The transition time was under 45 seconds. The recovery time from an abrupt increase of 50°C was under 25 seconds. This method is not sensitive to slight changes in τ_1, K_1 and 0. The Dahlin method is a convenient way to design a digital controller.

5. Control Software and Its Operation

A comprehensive control program, including the control algorithm, switching parameters and alarms, was complied for a Z-80 microprocessor. There are 20 programs including the main program and subroutines. The program takes up approximately 4 k in memory and is loaded on an EPROM.

The operation of the system is shown in Figure 5. The flowchart controlling the epitaxial process is shown in Figure 6. The flowchart for the control program to realize the temperature pattern shown in Figure 3 is shown in Figure 7.

The system is easy to operate. For example, the power is turned on at the beginning of the day. The CPU and PIO are automatically initialized. The program and data are loaded in the RAM from the PROM. There are three user defined keys as well. By pressing the "set" key, in a man-machine dialogue mode, silicon wafer processing temperature, HCl etching time, transition layer growth time and epitaxial layer growth time are entered sequentially (in decimal numbers). They are displayed again to check for errors. If HCl etching or transition layer growth is not required, then just enter 00 minute. By pressing the "prepare" key, the lines are "purged." After pressing the "process" key, epitaxial process begins in furnace number 1. When similar process is done later, it is only necessary to press the "process" key besides loading and unloading the wafer. The entire epitaxial process will be done automatically.

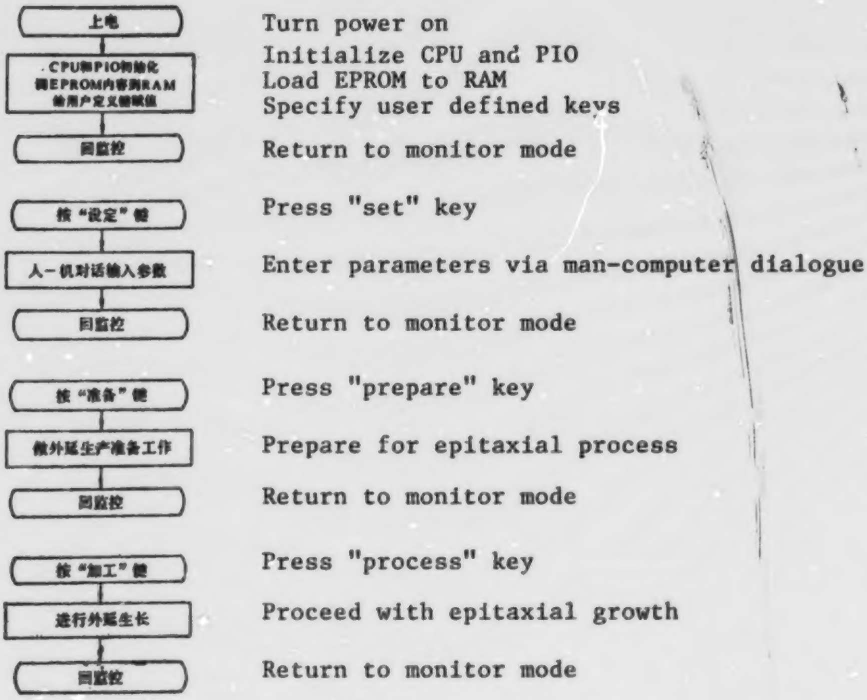
上电
Turn power on
CPU和PIO初始化
调EPROM内容到RAM
给用户定义键赋值
Initialize CPU and PIO
Load EPROM to RAM
Specify user defined keys
回监控
Return to monitor mode
按"设定"键
Press "set" key
人-机对话输入参数
Enter parameters via man-computer dialogue
回监控
Return to monitor mode
按"准备"键
Press "prepare" key
做外延生产准备工作
Prepare for epitaxial process
回监控
Return to monitor mode
按"加工"键
Press "process" key
进行外延生长
Proceed with epitaxial growth
回监控
Return to monitor mode

Figure 5. Operation of the System

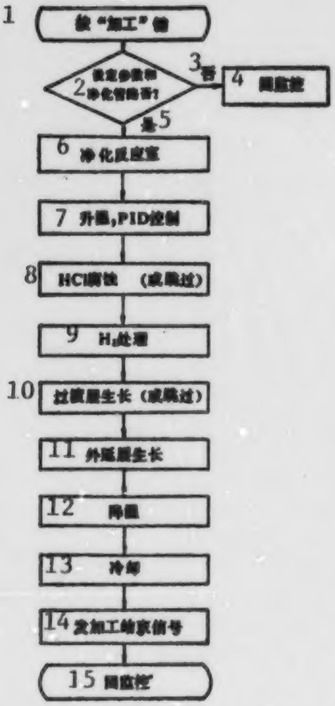
1
按"加工"键
2
设定参数和净化管路否?
3
否
4
回监控
是
5
6
净化反应室
7
升温,PID控制
8
HCl腐蚀 (或跳过)
9
H₂处理
10
过渡层生长（或跳过）
11
外延层生长
12
降温
13
冷却
14
发加工结束信号
15
回监控

Figure 6. Flowchart for Epitaxial Process

Key:

1. Press "process" key
2. Set parameters and clean lines?
3. no
4. Return to monitor mode
5. yes
6. clean reactor
7. raise temperature, PID control
8. HCl etching (or skip it)
9. H_2 treatment
10. grow transition layer (or skip it)
11. grow epitaxial layer
12. lower temperature
13. cool down
14. issue process finished signal
15. Return to monitor mode

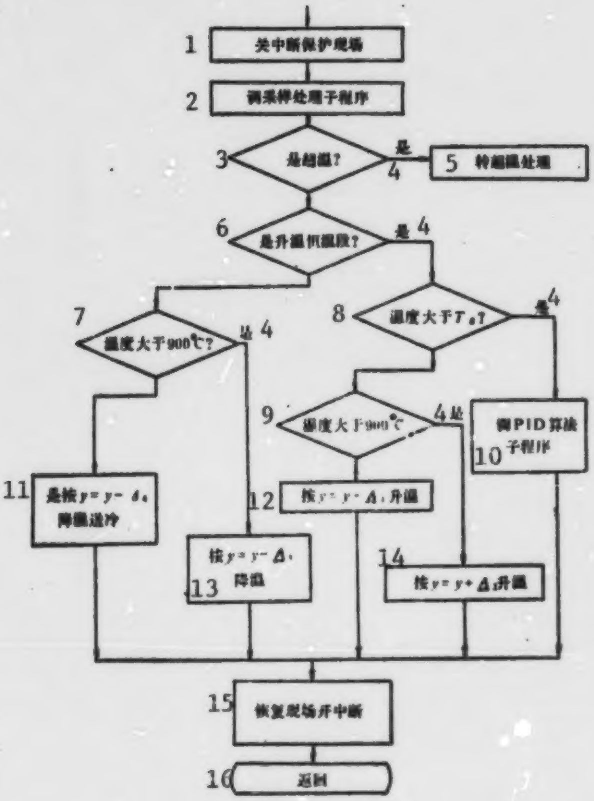
1
关中断保护现场
2
调采样处理子程序
3
是超温?
是
4
5
转超温处理
6
是升温恒温段?
是
4
7
温度大于900℃?
是
4
8
温度大于T_R?
是
4
9
温度大于900℃
4
是
10
调PID算法子程序
11
是按$y=y-\Delta_4$
降温送冷
12
按$y=y\cdot\Delta_1$升温
13
按$y=y-\Delta_3$
降温
14
按$y=y+\Delta_2$升温
15
恢复现场开中断
16
返回

Figure 7. Flowchart of the Temperature Control Program

Key:

1. Activate interrupt to protect site
2. Call sampling subroutine
3. Temperature overshoot?
4. yes
5. Switch to overshoot treatment
6. rising constant temperature segment?
7. greater than 900°C
8. greater than T_R?
9. greater than 900°C?
10. Call PID subroutine
11. Cool down according to $y=y-\Delta_4$
12. raise temp. according to $y=\Delta_1$
13. cool down according to $y=y-\Delta_3$
14. raise temp. according to $y=y+\Delta_2$
15. Shut off interrupt to restore site
16. Return

6. Conclusions

Based on on-site testing and continuous on-line operation, the system performs well. It is reliable and meets all the original design requirements. After it was put in the production line at Beijing Electronic Tube Plant, the yield of epitaxial processes is greatly improved.

The authors wish to thank Beijing Electronic Tube Plant for its support in the development of this system. They also wish to express their gratitude to engineers such as Guo Ruichun [6753 3843 2504] and Tan Wengui [6223 2429 6311] as well as students of Qinghua University such as Guo Jianping [6753 1696 1627], Meng Jinyan [1322 6855 1750], Meng Benxian [1322 2609 0341], Yin Shuxin [1438 2885 2450] and Quan Yi [0356 1704] for their assistance.

FOOTNOTES

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INTRODUCTION TO PROGRAM VECTORIZATION

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 14, No 3, May 86, pp 102-109, 113

[Article by Fan Zhihua [5400 2784 5478] of Changsha Institute of Technology: "An Introduction to Vectorization", manuscript received in February 1985]

[Text] Abstract: A systematic and comprehensive description of the basic concepts, principles, techniques and applications of the vectorization of serial arithmetic is given.

1. Main Frame Computer and Vector Computer

Since the 1970's, because of rapid advances in semiconductor and integrated circuit technology, a lot of high performance computers emerged. One type of computers continues to make breakthroughs in raising the computing speed. The average number of arithmetic operations per time unit (second) is increased astronomically toward the order of magnitude of billions. This is usually called "main frame" computers[1] (main frame for short). It is not characterized by speed alone.

Main frame computers are the best in terms of performance and size. They are the key equipment in solving major problems in scientific computation, engineering design and data processing. One way to attain super high speed is to increase its main frequency. The frequency of the CRAY-1 is 80 MHz.[2,3] However, the primary means is to drastically improve its capability in parallel processing.

The tremendous parallel processing capability of main frame computers is based on effective system structures such as pipeline technology, multifunction components, sample structure and multiprocessors.[1,3] To equip main frames with vector mechanisms is the current trend.[4] For example, the ILLIAC-IV, STAR-100, CYBER-203, CYBER-205, TI-ASC, CRAY-1, CRAY-1S, CRAY X-MP and CRAY-2S developed in the United States, the Model 757 computer[5] and galaxies computer developed in China, and the FACOM VP-100/200 super high speed computer in Japan[6] are vector computers. On the other hand, vector computers are at least one to two orders of magnitude higher in parallelism and they are main frame computers.

2. Vector Mechanism in Vector Computers

A vector computer is equipped with vector processors. For instance, the FACOM VP-100/200 computer developed by Fujitsu in Japan includes vector addition operators, vector logic operators, vector multipliers, vector dividers, masked registers, load storage and vector registers which are used to protect vector operation data (see figure 1).[6] Based on these hardware resources, a vector computer provides its users with vector mechanisms such as vector operation and vector chaining.

A vector is a non-empty ordered set of data of the same type. Vector operation deals with vectors. The vector length may be several hundreds, i.e. several hundred scalar operations are executed in parallel. From the programming point of view, CRAY-1 is equipped with eight vector registers. Each register is made of 64 64-bit elements (i.e. vector elements) and has 41 vector commands.[1-3] The FACOM VP computer equivalently has 16 times the vector registers as compared to the CRAY-1. It has 82 vector commands.[6]

Under the premise of vector operation, vector computers often use the vector chaining technique.[1,2] When the result of the previous command is the operand of the next command (which is frequently so in a program), in the same timing cycle, the vector register not only can receive the result from a functional component but also can deliver it to another functional component as the source for the next operation. Thus, two or more functional components are linked to resolve any contradictions related to the operand.

For example, we are looking for the product of a 5 column matrix X and a 5x125 matrix Y. The result is a 1x125 matrix Z:

$$Z_{1\times 125} = X_{1\times 5} Y_{5\times 125}$$

In scalar FORTRAN, two DO loops are used:

```
      DO 1 I=1,125
      Z(I)=0
      DO 1 J=1,5
1     Z(I)=Z(I)+X(J)*Y(J, I)
```

Excluding overhead in modifying and decising the loop control variable, it has to execute 125+125x5=750 statements. In vector FORTRAN, it only employs a simple sequence of six statements:

```
Z(1:125)=0
Z(1:125)=Z(1:125)+X(1)*Y(1, 1:125)
Z(1:125)=Z(1:125)+X(2)*Y(2, 1:125)
Z(1:125)=Z(1:125)+X(3)*Y(3, 1:125)
Z(1:125)=Z(1:125)+X(4)*Y(4, 1:125)
Z(1:125)=Z(1:125)+X(5)*Y(5, 1:125)
```

to be linked for execution. In addition, time overlap is utilized to further accelerate the computing speed.

Parallelism in computer system contains an abundance of contents[2,7,8]. In this paper only vector processing is discussed. Based on the classification introduced by M. J. Flynn in the United States, this parallel mechanism belongs to the single instruction multiple data stream system. This hardware based a parallel mechanism also requires that the data storage addresses be equally spaced.

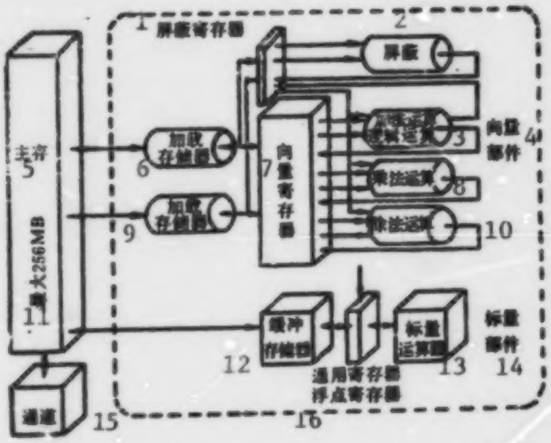

Figure 1. Block Diagram of Processor Part of FACOM VP-100/200

Key:
1. Mask register
2. Mask
3. Addition logic operation
4. Vector component
5. Main memory
6. Load storage
7. Vector storage
8. Multiplication
9. Load storage
10. Division
11. Maximum 256MB
12. Buffer register
13. Scalar operator
14. Scalar component
15. Channel
16. General register
    Floating point register

3. Embodiments of Programming Language

In order to use this hardware based vector mechanism, for the users, the concern is what descriptive means the programming language can offer.[9] Since the early 1970's, a great deal of studies had been done in vector languages. The mainstream is to add vector statements to high level serial languages.[10,11] For instance, the LRLTRAN on STAR-100, IVTRAN, CFD and GLPYNIR on ILLIAC-IV, STARAN on STARAN-IV, BSP FORTRAN on BSP, CRAY-FORTRAN on CRAY-1, vector FORTRAN on Model 757 and Glaxies, and vector ALGOL 60[12,13] are such high level vector languages.

Because data arrays are the data type used in high level languages, and one-dimensional array and its fragments as well as the fragment of a multi-dimensional array in a dimension are vectors, array operations are used in the expansion. The array processing capability of CRAY FORTRAN makes it possible to apply most of the operations defined for scalars in FORTRAN to arrays.[14] The four basic arithmetic operations and logic operations can be performed among arrays or between an array and a scalar. An array can be assigned. The array elements and its operations are conditionally selected. It is used as the input parameter of a function or as a process parameter.[15]

In the example in the last section, the statement

$$Z(1:125)=0$$

is a vector assignment statement. "1:125" is an abbreviation of the three-dimensional selection symbol "1:125:1" in which the subscript is selected from 1 to 125 at an increment of 1. The statement also assigns 0 to Z(1), Z(2), and "randomly". Similarly, the statement:

$$Z(1:125)=Z(1:125)+X(1)*Y(1,\ 1:125)$$

is a vector statement which calculates the following 125 multiplications and additions and assigns Z(1), Z(2),..., Z(125) in parallel:

$$\begin{gathered} Z(1)+X(1)*Y(1,\ 1) \\ Z(2)+X(1)*Y(1,\ 2) \\ \vdots \\ Z(125)+X(1)*Y(1,\ 125) \end{gathered}$$

The above vector operations are of the single instruction stream type. The individual processed data are stored in equally spaced intervals. This is ensured by the array compiler and storage distribution rule.

4. New Theories in Computer Science

It is known that one mind cannot be focused on two things. The traditional human thinking process is serial. Even in parallel events, things are being thought one by one. "Taking a walk in the park on Sunday and watching the flower show" can be considered as a parallel event. However, when people arrange this event, it is still a serial thinking process. The vector computer and high level vector language, nevertheless, ask us to describe serial thoughts with parallel statements. The following example show that simple substitutions will lead to mistakes.

Let us assume that there is an array A(0:101) in FORTRAN whose initial value is A(I)=I, I=0, 1, ..., 101. Therefore, the serial program

```
      DO 2 I=1, 100
2     A(I)=A(I+1)
```

individually assigns A(2) to A(101) to be A(1) to A(100), respectively. The corresponding parallel program should be:

```
3    A(1:100)=A(2:101)
```

The serial program

```
      DO 4 I=1, 100
4     A(I)=A(I-1)
```

individually assigns A(0) to A(99) as A(1) to A(100). The corresponding parallel program should be

```
5    A(1:100)=A(0:99)
```

The results of these four programs are shown in Table 1.

From Table 1 we find out that the vectorization of a pair of similar serial programs may end up with totally different results. DO loop 2 and vector statement 3 end up with the same results. The results of DO loop 4 and vector statement 5 are quite different.

As another example, the double loop

```
      DO 6 I=1, 100
      DO 6 J=1, 100
6     B(I, J)=B(I, J-1)**2-4*AC(I, J)
```

and

```
      DO 7 J=1, 100
      DO 7 I=1, 100
7     B(I, J)=B(I, J-1)**2-4*AC(I, J)
```

are equivalent. However, the operation of the inner loop of the former program requires iterations everywhere. Its parallel algorithm tree is shown in Figure 2. The depth is 99. The inner loop of the latter program involves independent operations. Its parallel algorithm tree is shown in Figure 3. The depth is 1. Obviously, the intrinsic parallelism is quite different.

Table 1. Results of Four Programs

1下标 2内容值 3语句	0	1	2	3	4	5	6	7	···	95	96	97	98	99	100	101
4初 值	0	1	2	3	4	5	6	7	···	95	96	97	98	99	100	101
DO 2	0	2	3	4	5	6	7	8	···	96	97	98	99	100	101	101
3	0	2	3	4	5	6	7	8	···	96	97	98	99	100	101	101
DO 4	0	0	0	0	0	0	0	0	···	0	0	0	0	0	0	101
5	0	0	1	2	3	4	5	6	···	94	95	96	97	98	99	101

Key:

1. Subscript	3. Statement
2. Contents	4. Initial value

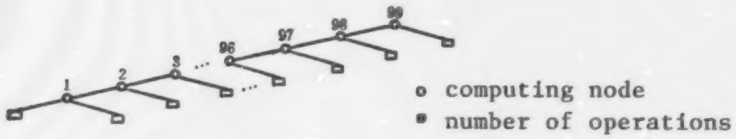

Figure 2. Algorithm Tree of Inner Loop of DO 6 Statement

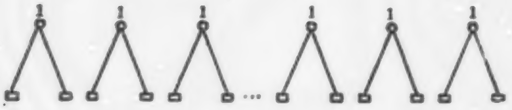

Figure 3. Algorithm Tree of Inner Loop of DO 7 Statement

In summary, as vector computers and higher level vector languages become available, in order to offer algorithms with higher intrinsic parallelism, the development of parallel algorithms is booming. To automatically identify the parallelism hidden in serial programs, automatic identification in vector operation (vector identification or vectorization) has become a new subject in the domain of computer science.

Parallel algorithms and vector identification go hand in hand. In general, the better the parallel algorithm used in the program, the more vector operations produced by vector identification will be. An analog can be found in geology to describe their relationship. The coal layer was formed in the Permocarboniferous Period. Today, geological theories are used as weapon in geological surveys to search for coal. Parallel algorithm is equivalent to the earth environment in the Permocarboniferous Period and vectorization is more or less equivalent to geological survey. The best theory cannot help us locate coal in a planet where coal does not exist. Similarly, the best vectorization theory cannot find vector operations from programs without any potential.

5. Basic Vectorization Theory

If a single instruction single data stream serial computer is considered as a dormitory with one seat for a person to dine in, then a vector computer is a restaurant with hundreds of seats to serve hundreds of people at the same time. The unit is "person * meal", i.e. meal per person. When we receive a reservation for 100 person * meals, we are not sure that there are 100 seats simultaneously available in the restaurant. We must first analyze a distribution plan. Let us consider the extremes. If there are 1 hundred people eating one meal, then we can arrange 100 seats for them to eat it at the same time. If one person is to eat 100 meals, then we have to serve one meal at a time even though there are empty seats available. It is not even possible to ask him to eat two meals together. The reason is obvious. In the former case, 100 meals are to be consumed by 100 people. They are independent. In the latter case, the same person will eat 100 meals. There are rigorous constraints. The meal served several hours after breakfast is lunch.

The vector mechanism in a vector computer his similar characteristics. The inner loop of DO 7 in the previous section is equivalent to 100 people eating one meal each. The inner loop of DO 6 is equivalent to one person eating 100 meals. The former can be vectorized while the latter cannot be.

Thus, the purpose of vectorization theory is to automatically identify parallelism in the source program based on an in depth analysis of the complex dependence of the data and to rewrite it in the vector form to obtain a vectorized target program. Obviously, the objective is to improve its efficiency. The equivalence of the source and the target program is a necessary premise. If vector identification is recognized as the identification work alone, then vectorization is more generalized, including the entire task of identification and rewriting.

Based on programming language theory,[16] a source program is statements in the source language and a target program is statements in the target language. The descriptive capabilities of the source language and target language determine the type and complexity of data dependence in the source and target programs; which also determine the ability of the vectorization theory to identify and to rewrite. To date, all vectorization methods are based on FORTRAN.[17-30] Most recent results[19-30] use FORTRAN77 as the source language[14] and use extended FORTRAN 77 with array processing capability such as that of the CRAY computer (VFORTRAN) as the target language.[15] (See Figure 4). The vectorization method thus derived is in general adaptable to various languages.

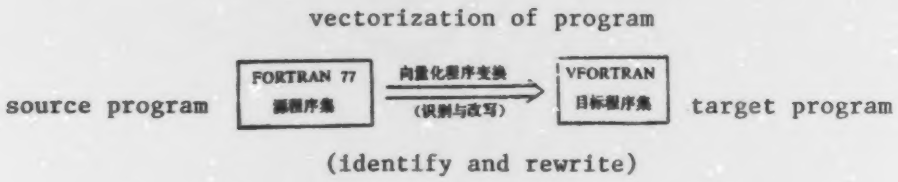

Figure 4. Program Transformation in Vectorization

A review of the history of the study on vectorization shows three areas of interest: explicit data dependence, implicit data dependence and identification instruction.

As mentioned before, the hardware based vector mechanism has two special features: single instruction multiple data stream and evenly spaced multiple data storage. Our programming design experience tells us that the statements in a DO loop can easily satisfy the requirements. Each statement in the DO loop gives an instruction (or a series of instructions) to be repeatedly applied to many data points, forming a single instruction multiple data stream. So long as the step remains unchanged, with the aid of the compiling system, the data storage happens to be equally spaced. On top of that, the loop concentrates the computing load of the program. Thus, all studies are focused on the vectorization of DO loops. Of course, it is also possible to form a loop with other statements (such as GOTO). However, based on the principle of programming structure design,[16,31,32] they can basically be transformed into DO loops by the source program itself.

The data dependence which is caused by the statements in the loop and covers a domain limited by the loop is an explicit dependence. Since the 1970's, there are many methods to identify explicit data dependence.[17-25, 28-30] They will be reviewed in the next section.

The data dependence which is caused by the statements in the loop and covers a domain beyond the loop is an implicit dependence.[28] To make sure that the source program is equivalent to the target program, vectorization theory must take implicit data dependence into consideration.

The current vectorization theories do not run the source program in the identification stage. Instead, they identify and rewrite in a "static mode." How to utilize dynamic information in static processing is an issue of great concern. Identification guidance instruction is an important way for the user to provide auxiliary information, particularly dynamic information which is lacking in static identification.

6. Review of Capability to Identify Explicit Data Dependence

The subscript tracking method,[19-25, 29,30] is established on the basis of using array elements as analytical nodes to solve the vectorization of all three basic modes (link, select and repeat)[16,31,32] in program structure design. Other methods such as coordinate method,[17] hyperplane method[18] and corelation analysis method[28] use the subscript as the analytical node.

To date, it is limited to the domain of the assigned statement loop. Through typical examples, their capabilities are reviewed in this section.

(1) For example, the following is a rigorous loop of assigned statements:

```
      DO 8 I = 1, N
      A(I) = B(I) * C(I)
      C(I) = B(I - 1)
8     B(I) = A(I + 1) * D
```

All methods described above can be used to identify and rewrite it.

(2) A loop of assigned statements which can be vectorized along a slant line, such as the following[18]

```
      DO 9 I = 2, 10
      DO 9 J = 2, 20
9     A(I, J) = (A(I + 1, J) + A(I, J + 1) + A(I - 1, J) + A(I, J - 1)) * *2
```

can be identified and rewritten by the hyperplane method.[18]

(3) A loop of assigned statements with a sequence change point,[19,21] such as the following

```
      DO 10 I = 1, N
      A(2 * I) = B(I)
10    B(I) = A(I) + 1
```

can be identified and rewritten by the subscript tracking method[20-22] and corelation analysis method.[28]

(4) A loop of assigned statements whose absolute step is greater than 1 and the initial DO variable cannot be estimated,[22,23] such as the following

```
      M = -N * * 2
      DO 11 I = M, 0, 2
      A(I) = 1
      A(2 * I) = 2
11    A(3 * 1) = 3
```

can be identified and rewritten by the subscript tracking method.[23]

(5) A loop of assigned statements with dynamic assigned step,[23] such as the following

```
      S = ABS(M - K)
      DO 12 I = 1, N, S
      A(2 * I) = B(I)
12    B(I) = A(I) + 1
```

can be identified and rewritten by the subscript tracking method.[23]

(6) A loop of assigned statements with unestimable initial value, final value, step and subscript expression coefficient,[29] such as the following

```
      :
      INTEGER M, N, L, S
      :
      DO 13 I = M, N, S * * 3
      A(L * I) = B(I - L) * C(3 * I + 1)
13    B(I - L) = C(I) * * 3 - A(L * I)
```

can be identified for vectorization in the original form by the subscript tracking method.[29]

(7) A loop with logical IF statements or IF blocks,[24] such as the following

```
      DO 14 I = 1, 10
      A(I) = B(I) * C(I) + D(I) * * 2
      IF (A(I).GT.4) THEN
      A(2 * I + 9) = E(I) * * 2 + 3 * A(I) + 5
      A(2 * I + 10) = 2 * F(I) * * 2 + A(I) + 1
      G(3 * I - 2) = B(2 * I - 1) * C(I) + A(2 * I + 9) - A(2 * I + 10)
      ELSE
      G(3 * I - 1) = A(I) * A(2 * I + 9)
      G(3 * I) = A(I) * A(2 * I + 10)
14    END IF
```

can be identified and rewritten by the subscript tracking method.[24]

(8) A loop with a triple control switch, such as the following

```
      DO 15 I = 1, 10
      A(I) = B(I) * C(I) + D(I) * * 2
      IF(A(I) - 4) 18, 17, 16
16    A(2 * I + 9) = E(I) * * 2 + 3 * A(I) + 5
      GOTO 20
17    A(2 * I + 10) = 2 * F(I) * * 2 + A(I) + 1
      GOTO 19
18    G(3 * I - 2) = B(2 * I - 1) * C(I) + A(2 * I + 9) - A(2 * I + 10)
19    G(3 * I - 1) = A(I) * A(2 * I + 9)
20    G(3 * I) = A(I) * A(2 * I + 10)
15    CONTINUE
```

can be identified and rewritten by the subscript tracking method.[25]

(9) A loop with unestimable initial value, final value, step and subscript coefficient and with logic IF statements and IF blocks,[30] such as the following

```
          ⋮
   INTEGER M, N, L, S
          ⋮
   DO 21 I = -2*M, N+L, S**2
   IF ((B(I-L)+A(L*I)).EQ.C(2*I-1)) THEN
   A(L*I)=B(I-L)*A(L*I)+D(I+1)
   ELSE
   B(I-L)=C(I)**3-A(L*I)
   END IF
21 D(I+1)=B(I-L)
```

can be identified and quasi-vectorized by the subscript tracking method.[30]

7. Applications of Vectorization Theory

To realize vectorization theory in engineering applications, the vector identifier is a key component to improve the operating efficiency of the vector computer. A vector identifier is a new software system of considerable size. On the vector computer developed by China, the earliest vector identifier is still in operation. It is being used in the following areas:

a. Transform Existing Serial Programs

Before vector computers became available, people already wrote a large number of serial programs which were successfully tested after investing an enormous amount of manpower and money. Now, we obviously would like to use these programs still "without making any changes." If we do that, since we did not include the vector mechanism when we wrote and tested these programs, the efficiency will in general be very low, leading to significant waste. Under the circumstance, vector identifier plays the role as a piece of "transplant software" to alter these serial programs so that they are automatically modified into new programs suitable for the operating environment of vector computers.

b. Modify Future Serial Programs

There are still a variety of computers in operation in parallel to vector computers. Because these computers can only execute serial programs, in order to fully utilize the results obtained on these computers, vector computers must have the capability to accept new serial programs and run these programs very efficiently. This capability comes primarily from the vector identifier. In addition, there will be considerable vector computer users who write and test their programs on other computers. The programs are run on vector computers only after they are compiled and debugged. These users will also introduce a lot of new serial programs. The vector identifier also plays the role of software transformation for these programs.

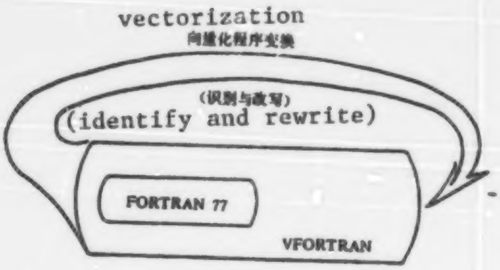

Figure 5. Program Vectorization by VFORTRAN

c. Modify Future Hybrid Programs

After vector computers are available, many users will write programs and run them directly on vector computers. They are not limited by serial FORTRAN. The system allows them to use direct vector statements.

However, as we mentioned before, our traditional way of thinking is serial. Unless in extremely simple cases, the most natural and dependable way for a programmer to express a parallel operation on a vector computer is still by using a serial program.

Thus, we will be facing a lot of hybrid programs with serial and parallel statements. In simple and obvious cases, vector operation will be used. In other areas, scalar operations are still being used. For this portion of the program, the vector identifier is again an optimization software. It can optimize the scalar operations which are masked by the complicated data dependencies into vector operations.

Because FORTRAN77 is a subset of VFORTRAN, the source program for the former must be that of the latter as well. From the viewpoint of program transformation, the function of the vector identifier is to extend the vectorization of FORTRAN77 to VFORTRAN (Figure 4) to the transformation of VFORTRAN itself (Figure 5).

d. Partially Modify Program Structure

As mentioned above, vector recognization is somewhat equivalent to a geological survey which basically identifies existing parallel components, instead of creating parallel components.

However, there are exceptions. For example, a vector identifier can alter the program structure within a small range to vectorize the program in Section 4 by changing DO loop 6 to 0 loop 7.

8. Conclusions

As vector computers become more popular, vectorization studies have both theoretical and practical significance. The essence of vectorization theory lies in the static recognition of dynamic data dependencies. Its progress not only requires knowledge in mathematics and computer science but also relies on the vector identifier. It is expected to be widely used in computer science and mathematics such as in parallel algorithm, cyclic optimization and data stream analysis.

Vectorization is being perfected and will continue to be an important part of computer science.

FOOTNOTES

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LIFE SCIENCES

CLONING OF THE $P_{7.5}$ PROMOTER FROM VACCINIA VIRUS

Shanghai SHENGWUHUAXUE YU SHENGWUWULI XUIBAO [ACTA BIOCHIMICA ET BIOPHYSICA SINICA] in Chinese Vol 18, No 1, Jan 86 pp 74-79

[Article by Feng Zongming [7458 1350 6900], Wu Xiangfu [0702 4382 3940], Wang Yuan [3076 0997], Chu Meijin [0328 5019 3866], and Li Zaiping [2621 6528 1627], Shanghai Institute of Biochemistry, Chinese Academy of Science]

[Text] Abstract: This article reports on the gene segment and cloning of 7.5K early protein $P_{7.5}$ promoter from vaccinia virus isolated from the genomic DNA of vaccinia virus, strain WR, collected in China. Use of restrictive endonuclease mapping, Southern hybridization, and DNA sequence analysis has confirmed that the $P_{7.5}$ promoter has been obtained. Comparison with data on the WR strain as reported in foreign literature shows its DNA sequence varies by a difference in one nucleotide. As one of the stronger promoters found in vaccinia virus, the $P_{7.5}$ promoter can be very useful for activating foreign gene expression.

The host environment for vaccinia virus used in genetic engineering studies is extensive and safe, and the capacity of the vaccinia virus genome to carry foreign genes is also great, thereby permitting insertion of many foreign genes. Hopefully, the vaccinia virus can be used this way to produce multivalent vaccine. For this reason, research during the past 2 years on the use of vaccinia virus to study the expression of foreign genes has been on the increase.[1-6] In this approach, expression of the inserted foreign genes need to be controlled by the vaccinia virus genome's own promoter gene, and not by any foreign promoter.

The basic purpose of developing such studies is to obtain a strong promoter from the vaccinia virus and to allow the expression of foreign genes which is controlled by this promoter in the vaccinia virological system to produce needed products. This article reports primarily on the cloning and assay of a comparatively strong $P_{7.5}$ promoter fragment from vaccinia virus, WR strain, collected in China. It also reports on its nucleotide sequence and its difference from known WR strain $P_{7.5}$ promoter.

Materials and Methodology

1. Vaccinia virus, WR strain. Provided by colleague Yan Zilin [0917 1311 2651] of the Bureau of Pharmaceuticals and Biologicals Assay and Certification, Ministry of Health.

2. Restrictive Endonucleases and T_4DNA ligase. Supplied by the Enzyme Tooling Section of our laboratory and from Biolabs.

3. Alpha-^{32}P-dATP (3000 Ci/mmol). From Amersham.

4. DNA isolation. Isolation of vaccinia virus DNA based on method used by Esposito et al.[7] Isolation and purification of DNA particles, their in vitro recombination and transformation, and selection of recombinants etc., are based on previous work done in this laboratory.[8]

5. DNA probe labeling. Reference made to Rigby's method.[9]

6. DNA gel transfer and hybridization. Reference made to Southern's method.[10]

7. DNA sequence analysis. Based on Maxam-Gilbert's method.[11]

Results

1. Cloning

We have completed the cloning of HindIII fragment of the genome of vaccinia virus, WR strain (yet to be published report). However, cloning was difficult, because the HindIII-A fragment was too large. Moreover, the linear double linear strands at the terminal end of the vaccinia virus' DNA molecule were joined to each other by a covalent bond to form a closed ring. Therefore, the HindIII-B and HindIII-C fragments at both ends of the DNA molecule were not able to be cloned. Coincidentally, the $P_{7.5}$ promoter we needed was located on the HindIII-C fragment of the left terminal of the vaccinia virus genome. If the HindIII-C fragment were to be cleaved with SalI enzyme, the $P_{7.5}$ promoter would be found in the SalI-C_1 fragment.[12] Toward this end, the recombinant plasmid containing the SalI-C_1 fragment must first be obtained, after which the $P_{7.5}$ promoter could be isolated from it.

In this experiment, we started by using a BglI-C fragment to replace the HindIII-C fragment, because the map positions of these two fragments are quite similar. Also, HindIII enzyme cleavage of vaccinia virus, WR strain, yields 15 segments, whereas cleavage with BglI yields only four segments A, B, C, and D,[13] the distance between C and B, D segments being rather larger and more easily isolated. We first isolated the BglI-C segment. Then the BglI-C segment and pBR322 were each cleaved with SalI, after which they were placed together for recombination and transformation. LB plates containing ampicillin and tetracycline were used to screen-select the Ap^rTc^s recombinants. DNA extracted from these recombinant plasmids then underwent enzyme cleavage analysis to select out the required cloning strain (Fig. 1).

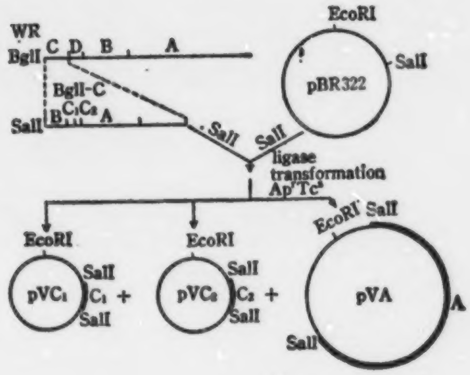


Figure 1. Diagram showing the cloning of DNA fragment containing the $P_{7.5}$ promoter

2. Analysis and Selection of Restrictive Enzyme Cleavage

Results of enzyme cleavage analysis of the WR strain's genome shows four SalI cleavage points on the BglI-C fragment, which yields five segments when cut with SalI. At the end of the left segment is the single-stranded ring formed by covalent bonding of the double-stranded DNA. At one end of the right segment is the SalI cleavage point; at the other, the BglI cleavage point. The DNA in these two segments cannot recombine with pBR322 cleaved by SalI. Using an antibiotic-treated LB plate to screen and select Ap^rTc^s colonies yields only SalI-A, Sal-C_1 and SalI-C_2 cloned strains[12] (Fig. 1), of which the A segment is 9 kb in length, while C_1 and C_2 segments measure only about 0.9 kb. Only analysis of recombinants in the 0.9-kb segments is needed to select out the required SalI-C_1 segment. Colonies are cultured in small quantities for quick extraction of the DNA. The recombinant plasmids of 0.9-kb length are first selected out. After this, enzyme cleavage analysis, selection, and determination are made of the inserted fragment, from which the cloned strain containing the $P_{7.5}$ promoter, that is, the SalI-C_1 segment, is selected out.

The results of work by Venkatesan at al[12] show that the SalI-C_2 segment contains three HpaII cleavage points, which are distributed fairly evenly and cut the C_2 segment of 0.9-kb length into very small fragments. However, the SalI-C_1 segment only has one cleavage point which is displaced toward one end of the 0.9 kb long C_1 segment (Fig. 2A), which may be used for selection purposes to distinguish between the two. As shown in Figure 2B, after the 0.9 kb long recombinant DNA has been enzyme cleaved by SalI, and the two recombinant plasmids are found to definitely contain insertion segments about 0.9 kb long (Fig. 2B, a and c), adding HpaII will show a segment of about 0.8 kb in the DNA of one recombinant (Fig. 2B, b), while the other strand is cut into numerous small fragments (Fig. 2 B, d). Quite possibly, recombinant a in Figure 2B may be the cloned strain containing the SalI-C_1 segment now called pVC$_1$, pVC$_2$ being the strain containing the C_2 segment. After the DNA of pVC$_1$ has been digested by enzymes SphI, PvuI, and HincII, the resulting segments (Fig. 2B, e~g) and sites are similar to those reported by Puckett et al,[14] in both the number of cleavage points and sites.

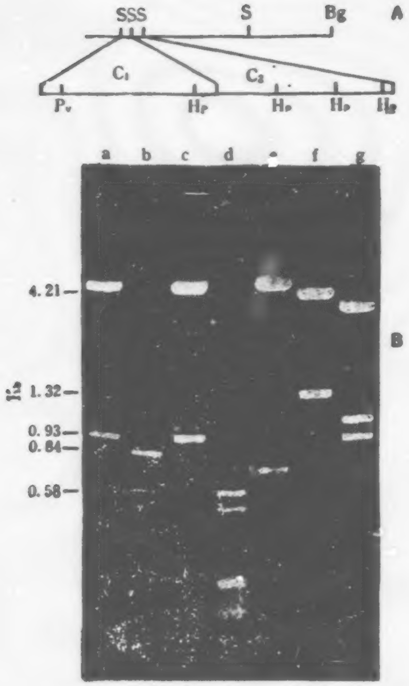


Figure 2. Enzyme cleavage electropherogram of pVC_1
a. pVC_1-SalI; b. pVC_1-SalI-HpaII
c. PVC_2-SalI; d. pVC_2-SalI-HpaII
e-g. Addition to pvC_1 of SphI, PvuI, and HincII.

As for the RsaI cleavage point, according to the restrictive enzyme cleavage electropherogram as described by Venkatesan et al,[12] the C_1 segment only indicates one RsaI cleavage point, which is also one of the points used by Smith et al[2] to isolate the 275-bp long $P_{7.5}$ (P_2) promoter. We have found three RsaI cleavage points on the SalI-C_1 segment. Figure 3 shows how the SalI-C_1 fragment (a), separated from pVC_1 is being digsted by HpaII(b) and RsaI(c); that there is a HpaII cleavage point on the SalI-C_2 fragment that shears out a small fragment of about 100 bp (Fig. 3,b); that shearing by RsaI results in four fragments, of which one measures 280 bp. What is interesting is the synergistic effect of using enzymes RsaI and HpaII together that eliminates the approximately 280-bp fragment in the digestion process. These results explain that this fragment is very likely to be the SalI-C_2 fragment that contains the $P_{7.5}$ promoter.

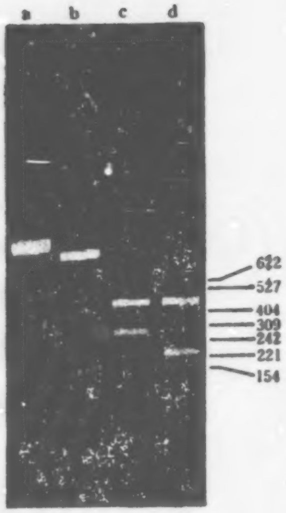


Figure 3. Enzyme cleavage electropherogram of SalI-C_1 fragment showing

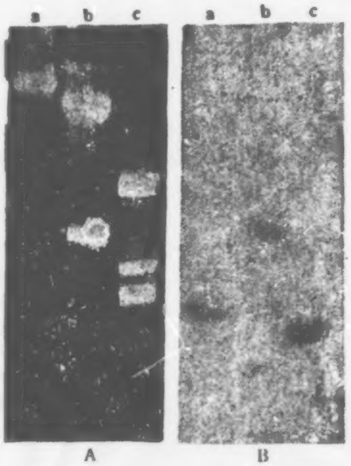
a. SalI-C_1 fragment; b. SalI-C_1 + HpaII;
c. SalI-C_1 + RsaI; d. SalI-C_1 +RsaI + HpaII

3. DNA Transfer and Hybridization

After we had obtained the DNA fragment that very likely contained the $P_{7.5}$ promoter, we obtained from Dr. Moss a vector plasmid pGS20 that contained the promoter $P_{7.5}$ from the 7.5K early protein gene of vaccinia virus. Then ^{32}P was used to label the approximately 280-bp fragment isolated from SalI-C_1 in a probe to be hybridized with pGS20. The results are noted in Figure 4 where the $P_{7.5}$ promoter in pGS20 was partially sheared out by EcoRI (Fig. 4A, a), confirming the fact that the ^{32}P-labeled probe can hybridize with it, while the other parts of pGS20 do not respond to hybridization (Fig. 4A-B, a and a'). Because a small fragment of polymerized connectors is located behind the $P_{7.5}$ promoter in pGS20, it shows up as being larger than the approximately 280-bp fragment we had obtained (Fig. 4, c and c'). This definitely proves the fact that we had found the DNA fragment containing the $P_{7.5}$ promoter.

Figure 4. Hybridization of $P_{7.5}$ promoter by Southern's method.

A. a. pGS20 + EcoRI; b. pVC_1 + SalI;
c. pVC_1 + SalI + RsaI.
B. Respective autoradiographs (a, b, c) of a, b, and c in A.



4. DNA Sequence Analysis

Mapping analysis of the restrictive endonucleases described above, and the results of DNA gel transfer and hybridization according to Southern's method, have confirmed the fact that we had obtained the $P_{7.5}$ promoter. Requirements for the promoter we need must have the distinguishing sequence of RNA polymerase, its synthesis sites and transcription initiation codon, and not contain the translation initiation codon ATG from the original code of the protein gene. This way, it will help the foreign protein gene inserted behind it to directly utilize its own translation initiation codon ATG to begin translation and avoid formation of a mixed peptide chain. For this reason, when the promoter is being isolated, the site for accurately excising the promoter must be accurately placed between the transcription initiation codon and the translation initiation codon ATG of its adjacent protein gene.

Toward this end, we conducted partial DNA sequence analysis of the $P_{7.5}$ promoter. Beginning near the translation initiation codon ATG of the 7.5K protein and going toward the transcription initiation codon, we analyzed a total of 142 nucleotides as shown in Figure 5. When the results are compared with those published by Venkatesan et al,[15] the only difference was found in the 48th nucleotide located upstream along the translation initiation codon ATG5' of the 7.5K protein. In their results, this site is occupied by C; in the fragment we obtained, this is occupied by T. No other differences were noted. This experiment to isolate the $P_{7.5}$ promoter has given us reliable data which indicates we need only shear off this DNA fragment and insert it into the appropriate site on the vaccinia virus, and the foreign gene spliced downstream on its 3' side will be expressed.[16]

```
a. AGTTTTTCAC CCATAAATAA TAAATACAAT AATTAATTTC
b. AGTTTTTCAC CCATAAATAA TAAATACAAT AATTAATTTC

   TCGTAAAAGT AGAAAATATA TTCTAATTTA TTGCACGGTA
   TCGTAAAAGT AGAAAATATA TTCTAATTTA TTGCATGGTA

   AGGAAGTAGA ATCATAAAGA ACAGTACTCA ATCAATAGCA
   AGGAAGTAGA ATCATAAAGA ACAGTACTCA ATCAATAGCA
                            RsaI

   ATCATGAAAC AATATATCGT CC
   ATCATGAAAC AATATATCGT CC
```

Figure 5. Partial DNA sequence analysis of $P_{7.5}$ promoter.
a. Venkatesan's results; b. Authors' results.

Discussion

Due to the unique characteristics of the vaccinia virus, the use of vaccinia virus DNA as vector units to construct recombinant viruses for studying the expression of foreign genes has received wide attention. At present, expression of such foreign genes as herpesvirus thymidine kinase,[1] hepatitis B surface antigen,[2,4] influenza virus hemagglutinin,[3] herpes simplex virus glycoprotein,[4] chloroamphenicol acetyltransferase (CAT),[5] and plasmodium sporozoite antigen[6] in vaccinia virus has become realities. To study these modes of expression, a vector plasmid which contains a fragment of vaccinia virus DNA into which the foreign gene can be inserted must first be constructed. To achieve a more pronounced expression of the foreign gene, a stronger promoter from a vaccinia virus fragment is inserted ahead of the foreign gene. Among several known vaccinia virus promoters, in vitro experiments have found promoter $P_{7.5}$ in the 7.5K early protein gene to be stronger.[14] Smith et al[2] have used it to successfully express hepatitis B surface antigen.

Consequently, we have isolated and purified viral DNA from vaccinia virus, WR strain, collected in China, conducted endonuclease mapping analysis, and established a gene bank. Following this, we have also cloned a DNA fragment containing the 7.5K early protein gene, and have analyzed and assayed its promoter. Using enzyme cleavage mapping, Southern hybridization, and partial DNA sequence analysis, we have determined the site of the $P_{7.5}$ promoter. When, the fragment is cut at the RsaI point, an approximately 280-bp fragment is obtained between the RsaI and SalI points. As the RsaI cleavage point is located 18 bp on the 5' side of the 7.5K protein gene's translation initiation codon, it does not contain the 7.5K protein's ATG codon, but contains rather, the RNA's polymerase synthesis locus and its transcription initiation codon. We can very conveniently excise this promoter, and insert it into the expression plasmid's vaccinia virus tk gene, and construct a transcribed expression vector that is controlled by the $P_{7.5}$ promoter. We have used it to successfully study expression of the hepatitis B virus surface antigen gene.[16] As for our DNA sequence analysis studies where the $P_{7.5}$ promoter discovered by us show a T and C difference with already published results by others, the effect of this difference on the strength of the promoter can pose an interesting problem.

Experiments using in vitro systems show the $P_{7.5}$ promoter to be more effective than other promoters.[14] However, the strength of these promoters within the genome has not been determined. For this reason, after the location and structure of the promoters concerned have been clarified, foreign genes can be constructed behind different promoters, undergo in vivo recombination and be placed in vaccinia virus genome for comparing the strength of the various promoters. Such an approach can be quite significant.

Using the vaccinia virus promoter to study the regulation and control mechanism of gene expression is quite meaningful. Recently, Weir et al[17] took a 366-bp fragment of the P_{LT} promoter from a 28K late protein gene and inserted it into an early protein--thymidine kinase (tk) gene, to study its effect on the expression of the CAT gene inserted behind it, and found CAT activity surfacing late, appearing only after DNA replication had begun. This explains the fact that this promoter only begins activity at this time. If a DNA inhibitor were present, this P_{LT} would remain inactive, completely unaffected by the early gene environment. On such a short DNA fragment are the on and off transcription signals, RNA polymerase recognition signals and synthesis loci and the transcription initiation site. Not only does selection of a simpler and quicker method to screen and select promoters have practical application value, it is also significant, through comparative analysis, in understanding the regulation and control pattern of true gene expression.

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FOOTNOTES

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CSO: 4008/1112

Applied Mathematics

FINITE ELEMENT ANALYSIS FOR TEMPERATURE FIELD PRODUCED BY MOVING HEAT SOURCE

Chongqing YINGYONG SHUXUE HE LIXUE [APPLIED MATHEMATICS AND MECHANICS] in Chinese Vol 7 No 5, May 86 pp 383-400

[English abstract of article by S. N. Atluri of Georgia Institute of Technology; and Kuang Zhenbang [0562 7201 6721] of Xi'an Jiaotong University]

[Text] Using the moving mesh finite element method, the authors discuss the temperature field produced by a moving heat source with variable thermal conductivity and with radioactive and convective boundary conditions in a wide velocity range. The temperature-time relationships at various velocities in the static and moving coordinate systems are studied. The steady-state temperature distributions at various velocities in the moving coordinate systems are given. The temperature field produced by the plastic deformation at the process region (a region very near the crack tip) is also studied, and the results show that the highest temperature at the process region is lower than 1000°C or 1832°F. (Paper received 9 May 1985.)

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MORE GENERALIZED HYBRID VARIATIONAL PRINCIPLE AND CORRESPONDING FINITE ELEMENT MODEL

Chongqing YINGYONG SHUXUE HE LIXUE [APPLIED MATHEMATICS AND MECHANICS] in Chinese Vol 7 No 5, May 86 pp 443-449

[English abstract of article by Chen Wanji [7115 8001 0679] of Dalian Institute of Technology]

[Text] According to recent studies of the generalized variational principle by Professor Qian Weizhang [6929 0251 7022], a more generalized hybrid variational principle for the finite element method is given. Thus, a new kind of generalized hybrid element model is established. Using the thin plate bending element with varying thickness as an example, various hybrid elements based on different generalized variational principles are compared. (Paper received 9 April 1985.)

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9717
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NEW LADDER-TYPE ACTIVE BANDPASS FILTER BY USE OF FDNR EMBEDDING, NIC

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 7, No 6, Nov 85 pp 401-410

[English abstract of article by Li Wenzhe [2621 2429 0772], and Hu Yun [5170 4596] of Beijing Institute of Posts and Telecommunications]

[Text] A new method of realizing elliptic ladder-type active bandpass filters is proposed. Comparing with the methods of the same category, it has the advantage of using fewer operational amplifiers, so the power consumption can be reduced. It also has the advantage of ease in adjustment. The low sensitivity property of ladder networks is maintained. The stability and the error of the fundamental circuits are analysed in detail. A sixth-order bandpass circuit is realized with this method and it shows that the experimental results agree pretty well with the theoretical design. (Paper received 3 May 84, finalized 10 Aug 84.)

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THEORETICAL ANALYSIS OF NEW TYPE OF RF SENSOR ON SATELLITE

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 7, No 6, Nov 85 pp 411-420

[English abstract of article by Zhang Jinbiao [1728 6855 2871] of Tianjin Institute of Technology]

[Text] A theoretical analysis of the performances of RF sensor proposed by B.K. Watson et al. (1981) on the large Satellite is carried out in this paper. By use of the method given here for dealing with the error signals, it makes the RF sensing system be indeed a big performance system. Except the case of b=1, $\gamma=0$ or $\pi/2$, the RF sensor is insensitive to depolarization of the coming waves, and because the horizontal channel does not couple with the vertical one, so it is obvious that the precision of dynamic tracking of the RF sensor on satellite is high and in ground station this RF sensing system will be a good one for tracking high-speed vehicles. (Paper received 25 Mar 85, finalized 16 Jul 85.)

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IMPEDANCE MATCHING ELEMENT OF DIELECTRIC IMAGE LINE

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 7, No 6, Nov 85 pp 421-427

[English abstract of article by Shi Meiqi [0670 5019 3825] of Department of Radio Electronics, Beijing University]

[Text] In this paper the wave impedance of dielectric image line as a function of geometry dimensions and frequency is analyzed. Both the necessity and the possibility of impedance matching are studied. An optimal matching element is put forward. Its bandwidth with VSWR⩽1.10 can be as wide as 10.5 GHz, when it is connected between two dielectric image lines with an impedance ratio of 4.7. Its properties are obviously better than those of classical type. (Paper received 16 May 84, finalized 21 May 85.)

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NEW FORMULAS FOR DESIGNING FREQUENCY DEVIATION OF CRYSTAL FM OSCILLATOR

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 7, No 6, Nov 85 pp 443-449

[English abstract of article by Ji Jian [0679 0256] of Nanjing Jinling Zhiye University]

[Text] On the basis of analyzing the oscillatory frequency of crystal oscillator, the general expression of the frequency deviation of crystal frequency-modulation oscillator is derived. The design formulas of the frequency deviation under optimum load condition and under condition of the modulating stage with series negative current feedback are also given. (Paper received 23 Apr 84, finalized 20 May 85.)

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I-V CHARACTERISTIC ANALYSIS OF SCHOTTKY AMORPHOUS SILICON SOLAR CELLS

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 7, No 6, Nov 85 pp 458-465

[English abstract of article by Xu Le [1776 2867] of Department of Physics, Nankai University]

[Text] The present paper introduces an experimental method for measuring the width of illuminated and short-circuited Ni/a-Si:H Schottky barriers. The current-voltage curves for the Schottky barrier solar cells under AM1, 100 mW/cm^2 illumination are calculated by using the parameters determined by experiments. The diffusion length of holes in a-Si:H obtained from the illuminated I-V curve is consistent with the results measured by the author with the surface photovoltage method in 1983. The factors affecting the fill factor are analysed on the basis of the calculated results. A comparison of the calculated results to the experiment's reveals that the very low fill factor of the solar cells measured is due to series and shunt resistances rather than the low diffusion length of the holes. (Paper received 16 Apr 84, finalized 20 May 85.)

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CIRCULARLY POLARIZED BACKFIRE ANTENNA WITH HIGH GAIN

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 7, No 6, Nov 85 pp 473-476

[English abstract of article by Song Ximing [1345 6932 2494] of The Huanghe Machine-Building Factory]

[Text] In this paper, a new type of high-gain circular polarized backfire antenna is presented. It is developed on the basis of equivalent reflector method proposed by the author (1979, 1981). A circular polarized wave is obtained by use of two orthogonal dipoles. The lengths of the two dipoles are so chosen that the real parts of their input admittances differ in 90°. The transverse dimension of the antenna is 2.24λ, the axial dimension is 2λ, the weight of the complete antenna assembly is only 1.2 kg. The gain measured is 17.5 dB, the axial ratio is 0.5 dB, VSWR is 1.16 at centre frequency. (Paper received 23 Apr 84, finalized 8 May 85.)

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Metallurgy

FORMATION OF (γ+γ') EUTECTIC AND CONTROL OF σ-PHASE IN HIGH Al-Ti CAST Ni-BASE SUPERALLOY

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp A93-A100

[English abstract of article by Zhu Yaoxiao [2612 5069 1366], et al., of the Institute of Metal Research, Chinese Academy of Sciences, Shenyang]

[Text] An investigation has been made of the various phases formed in order and composed under different temperatures during the process of solidification and segregation of alloying elements in a high Al-Ti cast Ni-base superalloy. The formation of (γ+γ') eutectic and the control of σ-phase precipitation are discussed. During solidification of the alloy, the dendritic segregation of Al and V is almost unespied, and that of Ti, Cr and Mo is positive, with that of Ti being the most serious. This may impel the formation of a segregation zone at the eutectic reaction and the enrichment with the σ-phase forming elements, e.g., Cr, Mo and Co, in the remaining liquid. Therefore, the increasing of the σ-phase transformation may be tended. However, the σ-phase may be avoided either by adjusting the ratio Al/Ti, taking advantage of the difference of the segregation behavior of Al and Ti, or by controlling the cooling rate after casting. (Paper received 21 November 1983; finalized 15 May 1985.)

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RELATIONSHIP BETWEEN $\gamma\to\varepsilon$ TRANSFORMATION TEMPERATURE $M_{\varepsilon s}$ AND COMPOSITION OF METASTABLE AUSTENITE REGION IN Fe-Mn-Al-Cr SYSTEM

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp A101-A108

[English abstract of article by Tian Xing [3944 5281], et al., of the Institute of Metal Research, Chinese Academy of Sciences, Shenyang]

[Text] The $\gamma\to\varepsilon$ martensite transformation temperature $M_{\varepsilon s}$ of 40 metastable austenitic alloys in an Fe-Mn-Al-Cr system was determined by dilatometry. As a result of the multicomponent linear regression, a formula for a linear relationship between $M_{\varepsilon s}$ and the alloy composition has been developed in that each wt-percent of Al, C and Cr decreases 51, 339 and 8°C of $M_{\varepsilon s}$ of the Fe-Mn alloy respectively. This is in agreement with the results of previous allied works and Ishida's calculation of the influence of alloying elements on the driving force of the $\gamma\to\varepsilon$ transformation in Fe-Mn alloys. A brief discussion on the effects of Al, C and Cr on $M_{\varepsilon s}$ is also made which refers to the mechanism of stacking fault for the $\gamma\to\varepsilon$ martensite transformation. (Paper received 18 October 1984; finalized 4 January 1985.)

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EFFECT OF HYDROGEN ON CREEP IN AUSTENITIC STAINLESS STEEL

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2,
18 Apr 86 pp A115-A118

[English abstract of article by Chu Wuyang [5969 2976 2254], et al., of
Beijing University of Iron and Steel Technology]

[Text] Dynamic charging does not influence the creep rate of type 321 austenitic stainless steel if the initial strain is less than 2 percent in which the amounts of evolving hydrogen after the test were below 1.5 ppm (by wt). However, the creep rate increased markedly when the initial strain was larger than 8 percent or when the specimen was precharged for a long time. In this case, the corresponding amount of evolving hydrogen was 5 to 12 ppm (by wt). (Paper received 1 February 1985.)

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BEHAVIOR OF Hf IN SOLIDIFICATION OF CAST Ni-BASE SUPERALLOYS

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp A119-A124

[English abstract of article by Zheng Yunrong [6774 6663 2837] of the Institute of Aeronautical Materials, Beijing]

[Text] Results of quantitative metallography, SEM, EDAX and EMPA studies of Hf on the solidification of cast Ni-base superalloys are presented. The Hf is found to lower the liquid temperature of the superalloys, with the final solidification temperature even dropping to 1130°C. The Hf may narrow down the range between the temperature lost during the interdendritic capillary feeding action and that of the solid, as well as decreasing the liquid content necessary for linking the interdendritic pools in the late solidification. The Hf-rich melts have superior fluidity, wettability and skin effects. These are the factors in increasing the castability of Hf-containing superalloys. The Hf is not found in the dendritic arms of the superalloys, but is exceedingly concentrated in the narrow interdendritic zones, usually in the form of Hf-rich phases. The Hf content in primary Hf-rich phases may be arranged in decreasing order of $MC_{(2)}$, $(Hf, Ti)_2SC$, Ni_5Hf, $MC_{(1)}$ and eutectic γ'. The Hf may depress the formation temperature of primary phases. The solidification temperatures of all Hf-rich phases are lower than 1250°C. These phases may precipitate from the molten pools with Hf concentration over 13 wt-percent at late solidification and may have an intergrowth feature.

(Paper received 21 September 1984; finalized 27 March 1985.)

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ON RAPIDLY SOLIDIFIED Cu-Zn-Al SHAPE MEMORY ALLOY

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2,
18 Apr 86 pp A125-A129

[English abstract of article by Jin Jialing [6855 0857 7117], et al., of Shanghai Institute of Iron and Steel Research]

[Text] The shape memory properties, microstructure and influence of heat treatment on them of Cu-24.9 wt-percent Zn-4.5 wt-percent Al alloy ribbon of different sizes prepared by the rapid solidification technique have been investigated by means of σ-ε and R-T curves, optical metallography, X-ray diffraction, SEM and TEM. The results show that the alloy ribbon is of a fine-grained β structure, about 20 μm originally, and grows to about 100 μm after water quenching from 720°C for 10 min. As for the alloy with a β+M structure at room temperature, its optimum shape memory properties may be obtained and the embrittlement by grain coarsening may be avoided. The complete memory recovery may be realized with strain of no more than 8 percent. The formation of granular relief and martensite on the specimen surface seems to be reversible during deformation under loading. (Paper received 6 October 1984; finalized 12 March 1985.)

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EQUILIBRIA OF Ce-Al-O AND Nd-Al-O IN MOLTEN IRON

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp A139-A148

[English abstract of article by Diao Shusheng [0431 3219 3932], et al., of Beijing University of Iron and Steel Technology]

[Text] The equilibrium of the Ce-Al-O or Nd-Al-O systems in molten iron was studied by separately smelting the radioactive isotope of ^{141}Ce or ^{147}Nd in an Al_2O_3 crucible filled with pure iron to form $^{141}CeAlO_3$ or $^{147}NdAlO_3$ around its inner wall. The content of dissolved Ce or Nd in iron was determined by means of radioassay and electrolysis in an organic electrolyte. The analysis of the dissolved Al in iron was obtained by colorimetry, followed by calculations. The activity of oxygen in a dissolved state in liquid iron was directly measured by solid electrolyte sensors made of $ZrO_2(MgO)$ tube. By extrapolation of the data obtained, the temperature dependence of the equilibrium constant of RE-Al-O in molten iron, K_{REAlO_3}, or of the interaction coefficient, e_{RE}^{Al}, may be described as:

For the reaction $CeAlO_{3(s)} = [Ce] + [Al] + 3[O]$

$$\lg K_{CeAlO_3} = -37900/T + 5.84$$

$$\Delta G^0_{CeAlO} = 173400 - 26.7T \text{ cal/mol}$$

$$e_{Ce}^{Al} = 20500/T - 13.53$$

For reaction $NdAlO_{3(s)} = [Nd] + [Al] + 3[O]$

$$\lg K_{NdAlO_3} = -24700/T + 0.69$$

$$\Delta G^0_{NdAlO_3} = 113030 - 3.16T \text{ cal/mol}$$

$$e_{Nd}^{Al} = 13500/T - 9.33$$

(Paper received 14 July 1984; finalized 20 January 1985.)

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PRECIPITATION DIAGRAM OF [Ce]-[O]-[S] IN LIQUID IRON AND ITS APPLICATION

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp A149-A155

[English abstract of article by Dong Yuanchi [5516 0337 4654], et al., of Beijing University of Iron and Steel Technology]

[Text] A space precipitation diagram of [Ce]-[O]-[S] in pure liquid iron has been constructed by the proper selection of recent and correct experimental thermodynamic data collected from allied equilibrium systems of RE-O, RE-S and RE-O-S. The quantitative correlation between the activity of oxygen or sulphur and the constitution of RE inclusions formed has been evaluated theoretically by thermodynamic calculations. This was verified well by the experimental results from which the correlation between the initial activities of oxygen and sulphur in liquid iron and the constitution of RE inclusions formed was also determined. (Paper received 17 April 1984; finalized 13 January 1985.)

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EQUILIBRIUM OF Fe-La-O-S SYSTEM

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp A156-A162

[English abstract of article by Chen Dong [7115 0392], et al., of Beijing University of Iron and Steel Technology]

[Text] A study was made of the equilibrium of the Fe-La-O-S system. The oxygen activity was directly measured by the solid electrolyte sensors made of a $ZrO_2(MgO)$ tube. The stability of La_2O_2S in the electrolytic separation and the content of La as a dissolved state in liquid iron were examined by means of radioassay and electrolytic isolation of inclusions in organic electrolytes under low temperatures. By extrapolation of the data obtained, the equilibrium constant of La_2O_2S may be described as:

$$1550^\circ C \qquad K_{La_2O_2S} = 3.81 \times 10^{-19} \qquad e_S^{La} = -4.1$$

$$1600^\circ C \qquad K_{La_2O_2S} = 6.45 \times 10^{-19} \qquad e_S^{La} = -4.8$$

$$1650^\circ C \qquad K_{La_2O_2S} = 7.41 \times 10^{-19} \qquad e_S^{La} = -4.2$$

$$La_{(l)} = [La]$$

$$\Delta G^0_{sol.} = -136700 + 59.82T, \ \gamma^0_{La} = 0.33 \ (1873 \text{ K})$$

It seems that the deoxysulphurizing effect of La is more intense than that of Ce, Nd and Y. (Paper received 18 June 1984; finalized 15 December 1984.)

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ESTIMATE OF FRACTURE TOUGHNESS FOR POLYCOMPONENT COMPOSITE MATERIALS

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp A175-A180

[English abstract of article by Li Zhonghua [262[illegible] 0022 5478] of Xi'an Jiaotong University]

[Text] The expressions for estimating fracture toughness of the polycomponent composite materials have been derived in terms of the fracture toughnesses and volume fractions of each individual component included. The expression, conforming to the mixed rule, of the upper $(n\to\infty)$ or lower $(n=1)$ bound value is also derived based on limit analysis. (Paper received 18 June 1984; finalized 8 November 1984.)

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KINETICS OF COMBUSTION OF PULVERIZED COAL IN RACEWAY BEFORE TUYERE OF BLAST FURNACE

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp B49-B62

[English abstract of article by Yang Yongyi [2799 3057 1355], et al., of Beijing University of Iron and Steel Technology]

[Text] A combustion efficiency study was made of partially burned pulverized coal, sampled from the raceway before the tuyere of two blast furnaces. Results show that the injected coal started to volatilize and burn just as it entered the blowpipe, which seems to be an important preheating and precombustion space before the raceway; however, it could not be burned completely in front of the tuyere. In order to replace more coke by injecting more coal, the laboratory simulation test on the combustion kinetics of the pulverized coal used by the two blast furnaces under conditions prior to tuyeres indicated it was technically possible by: pulverizing the coal down to 40 µm; enriching the blast with oxygen up to 30-40 percent; further raising the blast temperature; improving the injected coal distribution early in the blowpipe; consistently injecting the coal at all tuyeres and selecting a variety of coal which would be more combustible, e.g., bituminous coal is superior to anthracite. Petrographic observations of coal samples prior to injection and after being partially burned revealed that the bituminous coal burned violently and simultaneously, not only on the surface but also in the interior of its particles, while the anthracite burned mostly on the surface. Based on the theory of heat-transfer and mass-transfer, a set of mathematical models for the combustion of pulverized coal has been derived. By substituting the combustion conditions of both blast furnaces and the laboratory test furnace into the model and with the aid of a computer, a close approximation to what happens in actual practice has been obtained. (Paper received 25 February 1985; finalized 27 June 1985.)

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LIQUIDUS AND INTERMETALLIC COMPOUND IN Al-RICH REGION OF Al-Mg-Ce SYSTEM

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp B63-B67

[English abstract of article by Zheng Chaogui [6774 2600 6311], et al., of the Department of Chemistry, Beijing University]

[Text] The liquidus of the Al-rich corner in the Al-Mg-Ce phase diagram and the intermetallic compound, if any, formed in this region have been studied by thermal, EMPA, chemical analysis, metallography and X-ray examination. An intermetallic compound in the solid phase was observed to form a solid solution of a rather extensive range. The pseudo-ternary system Al-Mg_5Al_8-$CeAl_4$ is of the ternary eutectic type. Three surfaces corresponding to the primary crystallization of α-Al, Mg_5Al_8 and $CeAl_4$ respectively, three univariant curves associated with secondary crystallization and a ternary eutectic with a composition of about 12.6 wt-percent Ce and 26.0 wt-percent Mg at 446°C were detected. (Paper received 20 August 1984; finalized 1 February 1985.)

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COMPUTERIZED SIMULATION OF STRUCTURE OF CRYOLITE MELT

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp B68-B74

[English abstract of article by Xu Chi [1776 7459], et al., of Shanghai Institute of Metallurgy, Chinese Academy of Sciences; Li Qingzhi [2621 1987 5347], et al., of Shanghai Institute of Computational Technology; Shen Shiying [3088 2514 5391] of Northeast Institute of Technology, Shenyang]

[Text] The structure of molten cryolite has been investigated by computerized simulation using the Monte Carlo method. The radial distribution functions and some parameters describing the local structure of $3NaF \cdot AlF_3$ melt at 1283 K have been calculated. It is concluded that a part of the F^- ions in AlF_6^{3-} moves away from Al^{3+} ions after the melting of cryolite, forming $xNa^+ \cdot yF^-$ clusters with the Na^+ ions. The removal of a part of the F^- from AlF_6^{3-} makes it disintegrate into some local structures, such as AlF_4^- or AlF_5^{2-}. Some Al^{3+} ions are connected to each other by Al-F-Al bridges, forming ionic clusters, e.g. $Al_2F_7^-$, etc. It is also concluded that the distribution of the free space in molten cryolite is not uniform. There are more fissures and holes in $xNa^+ \cdot yF^-$ clusters and between AlF_4^- and $xNa^+ \cdot yF^-$ clusters. (Paper received 7 November 1984.)

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ON THE CRYSTALLIZATION OF AMORPHOUS Ni-BASE ALLOY

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp B75-B79

[English abstract of article by Wang Yuming [3769 3558 2494], et al., of Jilin University, Changchun]

[Text] The crystallization of amorphous $Ni_{83}Cr_7Fe_3Si_4B_3$ alloy was investigated under dynamic heating and isothermal annealing conditions. Identical crystallization and unaltered phases were revealed under both treatments. However, the initial crystallization was mainly due to the nucleation of crystals under dynamic heating, while crystal growth played a major role under isothermal annealing. It was also found that the microhardness approached its highest value just before the specimen was totally crystallized. (Paper received 5 July 1984; finalized 19 January 1985.)

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CORRELATION BETWEEN STRUCTURE OF ELECTROCHEMICALLY DEPOSITED (Fe, Co, Ni)-P LAYERS AND PROCESS CONDITIONS

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 2, 18 Apr 86 pp B80-B89

[English abstract of article by Jiang Xiaoxia [1203 2556 7209], et al., of the Institute of Metal Research, Chinese Academy of Sciences, Shenyang]

[Text] A study has been made of the structure of electrochemically deposited amorphous (Fe, Co, Ni)-P layers in relation to the process conditions, e.g., pH value, current density, metallic salt concentration, etc., by means of X-ray analysis, SEM and EPMA. Results show that the effect of the process on the structure is realized by changing the P content of the layer. When the P contained is over 8 percent, below 3 percent or between 3 and 8 percent, a layer may be constructed as an amorphous alloy, supersaturated solution or mixed structure respectively. The major factors affecting the structure of the deposited layer are found to be the concentration of NaH_2PO_2 and pH value of the bath. The structure of the layer may also be influenced by the potential of electro-deposition. The Fe-P, Co-P or Ni-P system is similar in amorphous structure when the highest thickness of the atomic face stack is 2.0, 2.5 or 6.5 nm respectively. (Paper received 6 January 1984; finalized 15 October 1984.)

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NEUTRON EMISSION BEHAVIOR IN LIGHT-CHARGED-PARTICLE ACCOMPANIED FISSION OF ^{252}Cf

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 289-296

[English abstract of article by Han Hongyin [7281 3163 6892], et al., of the Institute of Atomic Energy, Beijing]

[Text] The neutron emission probabilities for long range alpha (LRA), helium-3, triton and proton accompanied fission of ^{252}Cf are measured in a three-parameter experiment in which a liquid scintillation detector and a telescope are used to record the number of prompt neutrons and the energy of light charged particles. The average number of neutrons per fission for various particle accompanied fission events mentioned above are 3.13 ± 0.02, 3.09 ± 0.09, 2.95 ± 0.05 and 3.24 ± 0.07 respectively. The differentials of the average number of neutrons with respect to the energy of LRA particles and tritons are -0.037 ± 0.003 and -0.039 ± 0.008 neutron/MeV, respectively. The dependence of the width of neutron emission probability on LRA energy, described by Diven's empirical formula, and the correlations between the neutron number and triton energy have not yet been reported in the literature.

^{58,60,62}Ni(α,p) THREE-NUCLEON TRANSFER REACTIONS AND α OPTICAL POTENTIAL AMBIGUITIES

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 297-306

[English abstract of article by Wang Yuanda [3769 6678 1129] and Bao Xiumin [7637 4423 2404], et al., of the Institute of Atomic Energy, Beijing]

[Text] The differential cross sections are measured using a 26.0 MeV α particle for ^{58,62}Ni(α,α) ^{58,62}Ni and ^{58,62}Ni(α,p) ^{61,65}Cu reactions as well as a 25.4 MeV α particle for ^{60}Ni(α,α)^{60}Ni and ^{60}Ni(α,p)^{63}Cu reactions. Consistent calculations with the optical model and ZR DWBA are made for (α,α) and (α,p) reactions by using single, two, three and four nucleon optical potential parameters. For elastic scattering due to the α optical potential ambiguities, all the above optical potentials can reproduce the experimental angular distributions. However, the single, two and three nucleon potential, including Baird's mass systematics and Chang's energy systematics of α potentials, obviously cannot provide a reasonable fitting with the (α,p) reaction experimental data. Only the results from the four nucleon potential are in good agreement with the (α,p) reaction experimental data. This reveals that in the α-particle induced transfer reactions, the real depth of the α-nucleus optical potential should be rather deep.

CERIUM CROSS SECTION BETWEEN 12 AND 18 MeV

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 307-312

[English abstract of article by Teng Dan [3326 0030], et al., of the Institute of Atomic Energy, Beijing]

[Text] The cross sections for $^{142}Ce(n,2n)^{141}Ce$ and $^{140}Ce(n,2n)^{139}Ce$ from 12 to 18 MeV, $^{136}Ce(n,2n)^{135}Ce$ and $^{140}Ce(n,p)^{140}La$ from 13 to 15 MeV, and $^{138}Ce(n,2n)^{137m}Ce$ at 14.07 MeV are measured by the activation method. The neutron fluence is determined by the associated particle counting at 14.59 MeV for the $^{142,140}Ce(n,1n)$ reactions. The $^{138,136}Ce(n,2n)$ and $^{140}Ce(n,p)$ reactions are determined relative to the cross sections of the $^{142,140}Ce(n,2n)$ reactions at 14.07 MeV. The measured values are 1981, 1766, 925, 1244 and 6.70 mb for the $^{142,140,138,136}Ce(n,2n)$ and $^{140}Ce(n,p)$ reactions respectively.

MICROSCOPIC ANALYSIS OF (p,n) AND (p,p) SCATTERING ON TIN ISOTOPES

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 313-319

[English abstract of article by Ning Pingzhi [1337 1627 3112] of Nankai University, Tianjin]

[Text] Microscopic calculations are performed for the (p,n) charge exchange reaction and (p,p) elastic scattering on ^{116}Sn and ^{124}Sn at a proton energy of 24.5 MeV. The optical potentials and the isospin-coupling potential are generated from a density-dependent complex effective nucleon-nucleon interaction and the nucleon density distributions of the target nucleus. The (p,n) and (p,p) differential cross sections are calculated simultaneously by solving the coupled Lane equations exactly. The results of these microscopic calculations yield reasonable agreement with the measured values, even though they contain no adjustable parameters.

VALIDITY OF M-3Y FORCE EQUIVALENT G-MATRIX ELEMENT FOR CALCULATIONS OF NUCLEAR STRUCTURE IN s-d SHELL

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 320-324

[English abstract of article by Song Hongqiu [1345 1347 4428], et al., of Shanghai Institute of Nuclear Research, Chinese Academy of Sciences]

[Text] The matrix elements of the M-3Y force are adopted as the equivalent G-matrix elements and the Folded Diagram Method is used to calculate the spectra of ^{18}O and ^{18}F. The results show that the matrix elements of the M-3Y force as the equivalent G-matrix elements are suitable for microscopic calculations of the nuclei in the s-d shell.

TRANSITION POTENTIAL OF QUARK-ANTIQUARK PAIR (MESON) EXCHANGE IN CONSTITUENT QUARK MODEL

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 325-331

[English abstract of article by He Hanxin [0149 3352 2450] of the Institute of Atomic Energy, Beijing]

[Text] The amplitude to the lowest order for the exchange of quark-antiquark pairs ($q-\bar{q}$) between two three-quark clusters (nucleons) are obtained by QCD perturbation theory when the two nucleons overlap, and thus the transition potential for the exchange of the color-singlet ($q-\bar{q}$) pairs (mesons) between the two nucleons is defined. The non-relativistic approximation of this transition potential is also discussed and the expression of the potential is consistent with the one-boson exchange one. The nucleon-meson vertex structure is consistently included in this potential due to the quark structure of the hadron.

SHELL MODEL CALCULATIONS OF ^{90}Zr WITH WOODS-SAXON POTENTIAL

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 332-337

[English abstract of article by Yuan Haiji [5913 3189 7535] of Hangzhou University; and Shen Qingbiao [3947 1987 1753] of The Institute of Atomic Energy, Beijing]

[Text] In this paper a set of local Woods-Saxon potential parameters for the asymmetric nucleus ^{90}Zr are adjusted to perform the single-particle shell model calculations. The calculated results of the single-particle energies and the root mean square radius of the charge distribution are in good agreement with the experimental data. Based on previous studies, the nucleon densities, kinetic energy densities and spin densities of the asymmetric nucleus ^{90}Zr are calculated. Their shape and values are presented in this paper.

DEFORMED HF STATES OF EVEN TITANIUM AND CHROMIUM

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 338-343

[English abstract of article by Liao Jizhi [1675 4949 1807] of Sichuan University]

[Text] Using KB matrix elements, the deformed Hartree-Fock calculations for ^{44,46,48,50}Ti and ^{48,50}Cr nuclei are performed. The oblate, prolate and triaxial deformed solutions, as well as the solutions of some particle-hole excited configurations, are obtained. The results show that there is a form transition from mass number 48 to 50, and that the single-particle energy spectra are different not only for different mass numbers of the nuclei, but also for different configurations.

GLOBAL ANALYSIS OF NEUTRON DIFFERENTIAL ELASTIC CROSS SECTION CALCULATIONS WITH MICROSCOPIC OPTICAL POTENTIAL

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 344-351

[English abstract of article by Tian Ye [3944 6851], et al., of the Institute of Atomic Energy, Beijing; and Liu Wei [0491 3555], et al., of Northwest University, Xi'an]

[Text] Neutron differential elastic cross sections are calculated by the microscopic optical potential (S-MOP) and compared with available and independent experimental data as well as those calculated with Greenlee's phenomenological potential. The global analysis shows that for the original Skyrme forces, such as GS2 and SKa, without adjusting any parameters, S-MOP can reproduce the tendency of angular distributions, positions and absolute values of peaks and valleys of experimental data in the neutron energy region of 1-26 MeV for nuclei ranging from ^{12}C to ^{240}Pu. Thus, it is shown that S-MOP has a capability for predicting neutron differential elastic cross sections in optical model calculations for a nucleon even-even nucleus in a rather wide range of energies and nuclei.

FIFTH-ORDER ANGULAR ABERRATIONS OF INHOMOGENEOUS MAGNETIC FIELD WITH AXIAL SYMMETRY AND THEIR CORRECTION

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 352-360

[English abstract of article by Lu Hongyou [0712 3163 3731], et al., of the Institute of Atomic Energy, Beijing]

[Text] The fifth-order approximate solution is derived from the equation of motion for a charged particle in inhomogeneous magnetic field with axial symmetry by the method of successive approximation. The angular aberrations of different orders and the coefficients of the magnetic field to correct these angular aberrations are given.

TRANSPORT OF BEAM PHASE SPACES WITH NONCENTROSYMMETRIC CONFIGURATION THROUGH LINEAR FIELD

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 361-368

[English abstract of article by Fu Shinian [0265 0013 1628], et al., of the Institute of Atomic Energy, Beijing]

[Text] The transport theory of the beam phase spaces with noncentrosymmetric polygonal configuration $x + b_i x' - a_i = 0$ ($i = 1, 2, \ldots, n$) as well as noncentrosymmetric smooth convex close curve configuration $f(x, x') = 0$ through the linear field is developed. The formulas of the beam envelope of such beam phase spaces through the linear field are derived. Detailed calculations are worked out for typical examples to show the practical application of the theory.

SCHEME FOR RAISING BEAM BLOW-UP (BBU) THRESHOLD CURRENT OF CONSTANT IMPEDANCE STRUCTURE

Beijing YUANZIHE WULI [CHINESE JOURNAL OF NUCLEAR PHYSICS] in Chinese Vol 7 No 4, Nov 85 pp 369-378

[English abstract of article by Yao Chongguo [1202 0339 0948] of Nanjing University]

[Text] This paper presents a design scheme for a constant impedance structure that raises the BBU threshold current but does not degrade the performance of the structure. Two holes opened on disks in certain positions on the structure can stop the EH_{11} wave that brings about BBU, but they have little effect on the TM_{01} wave that accelerates electrons. Their function is equivalent to dividing the whole structure into n segments (n is usually two to four, depending on the length of the structure), so that the BBU threshold current roughly increases by the same factor of n.

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SYNERGISTIC EXTRACTION OF U, Th, Nd, Y BY BINARY SYSTEM OF AB SPECIES COMPOSED OF PMBP-TOPO--A STUDY USING TITRATION CALORIMETRY, KARL FISCHER TITRATION AND SOLVENT EXTRACTION

Beijing HE HUAXUE YU FANGSHE HUAXUE [JOURNAL OF NUCLEAR AND RADIOCHEMISTRY] in Chinese Vol 8 No 1, Feb 86 pp 1-7

[English abstract of article by Wang Wenqing [3769 2429 3237], et al., of the Department of Technical Physics, Beijing University; Li Xingfu [2621 6821 1133], et al., of the Institute of High Energy Physics, Chinese Academy of Sciences, Beijing; and Sun Pengnian [1327 7720 1628] of the University of Science and Technology of China, Hefei]

[Text] The present study is a detailed investigation of the synergistic extraction of uranium, thorium, neodymium and yttrium with a binary system of 1-phenyl-3-methyl-4-benzoyl-pyrazolone-5(PMBP) and trioctyl-phosphine oxide (TOPO) using a direct calorimetric titration method together with Karl Fischer titration and solvent extraction.

Calorimetric titration and temperature dependence studies of the extraction method allow calculation of the enthalpy and entropy changes associated with the synergic reaction. From the magnitude and signs of the ΔS values, it is possible to determine whether synergism is associated with the replacement of solvate water by the adduct molecule TOPO with no change in the coordination number, or with an expansion of the coordination sphere upon addition of the adduct molecule but no replacement of water. Uranium, thorium, neodymium and yttrium have been shown to form $UO_2(PMBP)_2(TOPO)$, $Th(PMBP)_4(TOPO)$, $Nd(PMBP)_3(TOPO)$ and $Y(PMBP)_3(TOPO)$ respectively. Water analysis is made by Karl Fischer titration. The equilibrium constants, enthalpy, entropy and free energy changes for the addition reaction are determined. The data indicate that the main driving force of the synergistic effect is the substitution of the coordinated water molecule by TOPO.

STUDY OF PREPARATION OF URANIUM (III) BY ELECTROLYSIS AND KINETICS OF REACTION OF U^{3+} WITH H^+

Beijing HE HUAXUE YU FANGSHE HUAXUE [JOURNAL OF NUCLEAR AND RADIOCHEMISTRY] in Chinese Vol 8 No 1, Feb 86 pp 26-31

[English abstract of article by Wu Jizong [0702 4949 1350] and Luo Wenzong [5012 2429 1350] of the Institute of Atomic Energy, Beijing]

[Text] In studying the factors affecting the percentage and rate of reduction of tetravalent uranium to the trivalent state by controlled potential electrolysis, it is found that the main factor is the cell constant β, which depends on the design of the cell system. The bigger the β, the higher the percentage and rate of the reduction. The kinetics of the redox reaction of U^{3+} ions with H^+ ions in hydrochloric acid determined by controlled potential electrolysis follows a second order reaction and can be represented as:

$$-d[U^{3+}]/dt = k[U^{3+}][H^+].$$

INVESTIGATION OF STABILITY OF U_3O_8

Beijing HE HUAXUE YU FANGSHE HUAXUE [JOURNAL OF NUCLEAR AND RADIOCHEMISTRY] in Chinese Vol 8 No 1, Feb 86 pp 53-55, 7

[English abstract of article by Feng Guoning [1409 0948 1337], et al., of the Uranium Mining Research Institute, Hengyang]

[Text] The source of the weight increase of U_3O_8 during storage is investigated. The main source comes from the absorption of water in the atmosphere. Probably $U_3O_8 \cdot H_2O$, $U_3O_8 \cdot 2H_2O$ and $U_3O_8 \cdot 3H_2O$ are formed. The increase in weight is related to methods of preparation, storage period and conditions during storage. It is shown that the process of water absorption is irreversible. Therefore, it is advisable to store the U_3O_8 in an ampoule, or to ignite the U_3O_8 at 850°C in a muffle furnace for two hours vefore use.

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Pharmacology

COMPARATIVE STUDY OF PHOTODYNAMIC EFFECT, PHOTOSENSITIVE SIDE ACTION AND TOXICITY OF SEVERAL CHINESE PHOTOSENSITIZERS

Beijing YAOXUE XUEBAO [ACTA PHARMACEUTICA SINICA] in Chinese Vol 21 No 1, 29 Jan 86 pp 7-11

[English abstract of article by Wang Naiqin [3769 5082 0530], et al., of Beijing Institute for Cancer Research, Beijing; and Ye Ailian [0673 1947 5571], et al., of Beijing Pharmaceutical Industrial Institute, Beijing]

[Text] In this paper, the photodynamic effect, photosensitive side action and acute toxicity of three new Chinese hematoporphyrin derivatives, HPS, LF-019 and Y-HPD, are compared with those of America-made photofrin II. The experimental method included: (1) the killing effect of the photosensitizer plus exposure to light on the MGC-803 cells; (2) the survival time of mice after receiving L_{615} cells pretreated with the photosensitizer and light; (3) the inhibitory effect on ^{3}H-TdR and ^{3}H-UR incorporated into DNA and RNA; (4) the uptake and storage of photosensitizers in L_{1210} cells; (5) the ear and skin indexes showing skin photosensitive side action and (6) the LD_{50} in mice.

The results show that the photodynamic effect of the three Chinese photosensitizers was more potent than that of photofrin II. In the three Chinese photosensitizers, except for the skin photosensitive side action, Y-HPD was more potent than HPS or LF-019 in the killing effect of MGC-803 cells, the survival time of L_{615} mice, the inhibitory effect of nucleic acid biosynthesis and the content of photosensitizers in L_{1210} cells. The acute toxicity of Y-HPD was lower than that of other photosensitizers. (Paper received 4 May 1985.)

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STUDIES OF SYNTHESIS AND STRUCTURE-ACTIVITY RELATIONSHIPS OF N-(α,β-DISUBSTITUTED-4-CHLOROCINNAMYL)-SEC-BUTYLAMINES

Beijing YAOXUE XUEBAO [ACTA PHARMACEUTICA SINICA] in Chinese Vol 21 No 1, 29 Jan 86 pp 20-28

[English abstract of article by Peng Shiqi [1756 1597 1142], et al., of the College of Pharmaceutical Sciences, Beijing Medical University, Beijing; and Chen Suming [7115 4790 2494], et al., of the Institute of Chemistry, Chinese Academy of Sciences, Beijing]

[Text] In this paper the synthesis of 13 N(α, β-disubstituted-4-chlorocinnamyl)-sec-butylamine derivatives (4Ea, 4Eb~e, 4Zb~e, 6Ea~b, 6Za~b) are reported. The configuration of pairs of geometrical isomers has been assigned by NMR. Four compounds have been configurationally confirmed by X-ray diffraction. The θ_1 (the twist angle between the phenyl ring and the carbon-carbon double bond) and θ_2 (the twist angle between the carbonyl group and the carbon-carbon double bond) of stable conformations of the compounds have been calculated by the EHMO method. The values of θ_1, θ_2, and anticonvulsant activity (ED_{50}) of 18 compounds are given here. The relationships of θ_1 and θ_2 and the anticonvulsant activities of these compounds are discussed. The pattern in which these compounds bind with the receptor in order to produce the anticonvulsant effect is tentatively proposed. (Paper received 12 February 1985.)

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China Report

SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

KANG SHIEN AT DAQING PETROCHEMICAL COMPLEX CEREMONY

OW041408 Beijing XINHUA in English 1351 GMT 4 Aug 86

[Text] Daqing, 4 August (XINHUA)--The completion and inauguration of the first-phase project of the Daqing Petrochemical complex were marked at a ceremony in this oilfield today.

The complex will be able to produce 300,000 tons of ethylene a year when the whole project is completed in 1988.

The ceremony was attended by 1,000 people, joined by more than 160 guests from Japan, the United States, Britain and Federal Republic of Germany.

Most installations of the complex, 12 plants and 71 auxiliary plants, were imported from these 4 countries.

Ethylene is the primary raw material for producing textiles, plastic products, building materials, chemicals and other consumer goods. Ethylene output is therefore regarded as an indicator of the development of a country's petrochemical industry.

With an investment of 4.2 billion yuan, the Daqing petrochemical complex, a computerized enterprise, uses light hydrocarbon from the Daqing oilfield as its main raw material.

It is another key construction project China has undertaken after three other ones: The Gezhouba Dam on the middle reaches of Hubei Province; the Baoshan Steelworks in Shanghai; and a railway line between Yanzhou, Shandong Province, and Shijiusuo Port in the same province.

A total of 2.64 billion yuan has been spent on the first-phase project. The first 5 commissioned plants and other assistant facilities cover 150 hectares and involve 50,000 sets of equipment. The pipelines there total about 1,600 kilometers in length.

The major plant of the first-phase project is 36 meters high, with the largest pipeline being 1.1 meters in diameter and the smallest, 8 millimeters.

The first five commissioned plants will produce 200,000 tons of polyethylene granule annually, the basic raw material for the plastics industry, as well as other raw materials. This will increase China's per-capita amount of plastics to 1.5 kilograms from 0.9 in 1980.

The first-phase project will also raise China's ethylene output by 50 percent, to reach 900,000 tons a year.

Construction of the Daqing petrochemical complex is being undertaken by 50,000 workers.

The State Council, China's highest governing body, today sent a message of congratulations to the complex, calling it a new success in the country's modernization program.

State councilor Kang Shien cut the ribbon for the operation of the first-phase project and extended greetings to the builders on behalf of the State Council.

Attending the ceremony were leading officials of the China Petrochemical Corporation, Heilongjiang Province and other government departments, as well as diplomatic envoys and representatives of 40 firms and banks from the four foreign countries.

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NEW SHANGHAI INDUSTRIAL CENTER UNDER CONSTRUCTION

OW051030 Beijing XINHUA in English 0608 GMT 5 May 86

[Text] Beijing, 5 May (XINHUA)--A micro-electronics center, which aims at attracting foreign investment and import of foreign technology, is under construction in Shanghai, according to the WEN HUI BAO, a Shanghai-based daily.

The Caohejing Industrial Center, 11 kilometers southwest of the city will focus on developing computers, large-scale integrated circuit, optical-fibre telecommunications, laser and other micro-electronic inudstries.

The new industrial area has attracted business persons from a dozen of countries, including Federal Germany, Japan and the United States.

It covers 1.7 square kilometers, with research institutes, parks and "smokeless" enterprises in the surrounding.

Projects planned include a 10,000-line telephone exchange, a 220,000 volt-transformer station, and three gas tanks, factories, as well as office buildings, information centers, hotels, trade, commerce and banking facilities.

Local officials expect enterprises with exclusive foreign capital, joint ventures and cooperative businesses to be set up in the new industrial area, the WEN HUI BAO said.

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NATIONAL DEVELOPMENTS

RENMIN RIBAO REPORTS MICROCOMPUTER INDUSTRY PLANS

OW021240 Beijing XINHUA in English 1207 GMT 2 Jul 86

[Text] Beijing, 2 July (XINHUA)--To meet internal needs, China must increase the output of microcomputers, Zhang Xuedong, vice minister of the electronics industry, said in an aritcle printed in today's PEOPLE'S DAILY.

During the Seventh 5-Year Plan period (1986-1990), he said, microcomputer needs are expected to double. This year, there are already orders for 10,000 of the moel 0520c "changcheng" (great wall) microcomputer. More than 54,200 computers were installed last year.

"Self-sufficiency in microcomputers can save hard currencies for the state, facilitate repair and technical services, and improve efficiency of the clients' investment," he explained.

At a recent national meeting, a plan was drawn up for the industry, which will be administered by the Ministry of Electronics Industry.

According to the plan, the industry will manufacture simple microcomputers first and them complicated ones. Emphasis will be on peripheral equipment, including disc drives and monitors.

In 1990, the value of peripheral equipment is expected to be 2 billion yuan, accounting for 33 percent of the total computer industry. The state will support the industry by providing tax breaks and loans.

The computer industry employs 90,000 workers, including 17,000 technicians. Over the past few years, it imported assembly lines with an annual capacity of 50,000 microcomputers and developed some updated products, including Chinese processing systems.

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TIANJIN TO BECOME ELECTRONIC MACHINERY BASE

OW211116 Beijing XINHUA in English 1050 GMT 21 Aug 86

[Text] Tianjin, 21 August (XINHUA)--Tianjin, a major north China industrial and port city, has been chosen to become an electronic controlled machinery development base.

The endeavor will be guided by a joint committee of the Chinese Ministries of Machine Building and Electronics, which was formed today.

A committee official said that the move aims at meeting the challenge of the galloping technological revolution, which is focused on spreading the use of electronic computers.

Work will be done to introduce microelectronic technology into the manufacture of machine building, electronic appliances and instruments and meters to improve the traditional products.

The electronic controlled machinery will cover a complete range, from production lines to home appliances and toys, which will help open a new vista for raising productivity and enriching the people's life, the official said.

The first projects will begin in the latter half of this year, and included will be development of duplicators and electronic medical apparatus, numerical controlled machine tools, renovation of old type machine tools and development of information management systems, the official said.

A number of enterprise groups and production-research schemes will be formed to facilitate the experimental projects, he said.

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SATELLITE LAUNCHING SERVICE SAID 'PURELY COMMERCIAL'

OW271033 Beijing XINHUA in English 0715 GMT 27 Sep 86

[Text] Beijing, 27 Sep (XINHUA)--China's satellite launching service is purely a commercial venture, and the country has no intention to take advantage of it to acquire foreign technological information. The country is willing to invite customers who worry about the release of their satellite technology to send experts to China to supervise the launches, said Sun Jiadong, vice-minister of space industry, in an interview with PEOPLE'S DAILY.

In a report today, the paper reviewed the progress of China's space technology and policies for satellite launching service.

Over the past year, Swedish and American firms have requested the launching of six satellites using China's "Long March 2 and 3" carrier rockets, the paper added.

Australia, Brazil, Britain, Canada, and the Netherlands as well as U.S. telecommunications and broadcast companies have held direct or indirect discussions with China about satellite launches.

China launched its first man-made satellite in 1970. Since then, it has sent another 17 into the space, including two earth synchronous satellites.

China is now able to handle international orders to launch 10 to 12 commercial rockets and is developing carrier rockets with greater thrust to meet the needs of the world market, the paper said.

China will charge at least 15 percent less than the rates offered by foreign countries for the service, and its People's Insurance Company will offer low premiums to those using the launch.

China's space industry minister will complete a comprehensive quality control program this year to ensure the success of launches.

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CSO: 4010/9

NATIONAL DEVELOPMENTS

SATELLITE RETURNED TO EARTH ON SCHEDULE

OW110909 Beijing XINHUA in English 0856 GMT 11 Oct 86

[Text] Beijing, October 11 (XINHUA)--Today a land resource survey satellite carrying valuable technological data returned to China on schedule.

The head of China's satellite launch telemetry and control system department told XINHUA that the satellite was launched on Monday by a "Long March-2" carrier rocket at Jiuquan launching center, northwest China.

The People's Insurance Company of China provided economic insurance for the launch.

The official said, "all instrumentation on the satellite worked normally and it returned to the earth as planned."

He added, this is China's 19th satellite since the first launching in 1970, which include satellites for telecommunications and broadcasting, scientific exploration and technical experimentation.

The valuable data obtained by this satellite will be used for land surveillance, mineral prospecting, environmental protection, and other uses.

Min Guirong, president of the Chinese Academy of Space Technology, said, in an exclusive interview with XINHUA, "China has launched and recovered eight satellites with a 100 percent success rate since 1975."

"The satellites worked in planned orbits for three or five days and then all returned on schedule," Min said.

"Compared with other satellites," Min said, "the newest one has been fitted with special technology, and its photo taking capacity was improved, resulting in better pictures."

Showing clear satellite pictures, the specialist said, "the satellite pictures and other data will be used in surveying national land, prospecting resources, drawing inland and coastal maps and planning new cities.

In order to meet the needs of its modernization program, China will redouble its efforts in developing its space industry, which includes speeding up the development of practical satellites for use in communications, meteorology and the surveillance of land resources.

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BRIEFS

SHANGHAI'S NEW DATA SYSTEM--A management, production, and marketing data collecting and distributing system developed by the Shanghai Fasteners Company and Shanghai's Jingju County Welding Materials Technology Institute recently passed assessment tests. This computer-controlled collecting and distributing data system is very practical. Better economic results have been attained after the application of the system. [Text] [Shanghai City Service in Mandarin 1000 GMT 17 Aug 86 OW] /12232

GUANGDONG ELECTRONICS INDUSTRY--During the Seventh 5-Year Plan period, the electronics industry of Guangdong Province will lay stress on the development of consumer electronic products. Since the beginning of 1980, our province has begun making radio recorders and television sets. Last year, the output of television sets reached 700,000 sets and the output of radio-recorders 2.8 million sets, ranking first in the whole country. Our province, Shanghai, Beijing, and Jiangsu have become the bases of the electronics industry. By 1990, the annual output of television sets will reach 1.3 million sets, the great majority of which will be color television sets. The annual output of radio-recorders and radios after 5 years will respectively be 400 percent and 175 percent greater than last year. Our province has now not carried out batch processing of videocorders, but after 5 years, the annual output will reach 130,000 sets. [Summary] [Guangzhou Guangdong Provincial Service in Mandarin 0300 GMT 1 Sep 86 HK] /12232

BEIJING PHENOL ACETONE EQUIPMENT--A large phenol acetone production assembly, the first of its kind in China and a key project of Beijing Municipality, has been completed and formally went into operation at the Yanshan Chemical Industrial Plant on 20 September. This apparatus, with an annual production capacity of 80,000 tons of phenol acetone, was built by the state with an investment of about 150 million yuan. Upon going into operation, the equipment can earn 100 million yuan of profits for the state every year. [Summary] [Beijing BEIJING RIBAO in Chinese 21 Sep 86 p 1 SK] /12232

HUNAN ELECTRONIC INDUSTRY--The provincial Electronic Industry Bureau has strengthened macroeconomic control and guidance over the enterprises which have been transferred to a lower level and has done a good job in coordinating work and providing services. This has resulted in a new situation in scientific research and production for the whole bureau. By the end of September, the bureau had completed scientific research on 31 items, and its industrial output value reached some 310 million yuan. [Summary] [Changsha Hunan Provincial Service in Mandarin 0100 GMT 3 Oct 86 HK] /12232

SHANDONG EQUIPMENT INSTALLATION--Beijing, 12 September (XINHUA)--A fertilizer plant in Shandong Province replaced an important piece of equipment today without stopping production. A new 325-ton tower will make it possible for the Qilu Petrochemical Company to produce 300,000 tons of ammonia a year. The replacement operation, which was the first in China, saved a loss of more than 1 million yuan (270,000 U.S. dollars). [Text] [Beijing XINHUA in English 1059 GMT 12 Sep 86 OW] /12232

SICHUAN PRINTED CIRCUIT PRODUCTION--Chengdu, 27 September (XINHUA)--A precision multi-layer printed circuit board production line has been put into operation in Chengdu, capital of southwest China's Sichuan Province. The project was completed in just 15 months by an Australian company. The production line can produce 30,000 square meters of double-faced precision printed circuit boards with 2 to 14 layers to be used in space technology, and electronic instruments and meters. The Xinxing Instrument Factory has received letters and cables from a dozen countries and regions including the United States, Japan, Federal Germany and Hong Kong, asking for the products. The first order has already come from Australia. [Text] [Beijing XINHUA in English 1611 GMT 27 Sep 86 OW] /12232

PRC SOFTWARE PROTECTION LAWS--Beijing, 21 October (XINHUA)--China is preparing a law to protect the integrity of advanced foreign and domestic software, a senior official said here today. Xie Gaojue, vice-minister of the electronics industry, told foreign participants at the Sixth Business Leaders Symposium held here at the ministry and the Ministry of Posts and Telecommunications are negotiating with foreign companies on the import of advanced digital telephone exchanges. The two ministries are cooperating to draft regulations concerning usage of the equipment, he said. Software has high-priority in the development of China's electronics industry during the Seventh 5-Year Plan period (1986-1990), and the new law is expected to help promote China's software technology, the minister noted. Meanwhile, China will continue to import advanced software technology and protect it with the law. [Text] [Beijing XINHUA in English 1511 GMT 21 Oct 86 OW] /12232

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APPLIED SCIENCES

BIFILAR-HELIX WIGGLER FOR FREE-ELECTRON LASER DESCRIBED

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 6, No 8, Aug 86 pp 673-678

[Article by Chu Cheng [5969 2052], Lu Zaitong [7120 6528 6639], Shi Ruigen [2457 3843 2704], Zhang Lifen [1728 4539 5358], and Hu Yu [5170 3558] of the Shanghai Institute of Optics and Fine Mechanics, the Chinese Academy of Sciences; first paragraph is source supplied abstract]

[Text] Abstract: We have developed a bifilar helix wiggler used in a Raman free electron laser and measured its operating characteristics. Using this wiggler as a pump source, we have obtained free electron laser radiation and carried out preliminary parametric studies.

I. Introduction

Bifilar helix wigglers[1-3] have recently been used as a pump source for the Raman free electron laser. The right-circularly polarized field produced by the wiggler interacts with the magnetic field that confines the electron beam. Under the proper combination of the parameters, this interaction effectively pumps the free electrons and leads to a large laser gain and a high quantum efficiency. We applied this pumping technique to a Raman free electron laser[4]. Experiments show that the bifilar helix wiggler can not only provide a laser output like the iron ring wiggler, and it is also more convenient for parametric studies.

II. Determination of the Principal Parameters of a Bifilar Helix Wiggler

The two principal parameters of a right-circularly polarized wiggler field are the intensity and the period. We first examine the intensity. For a bifilar helix with current I, shown in Figure 1, the magnetic potential φ in Gaussian units is given by[5]:

$$\varphi=\varphi_I+\varphi_{-I}=-\frac{16\pi I}{c\lambda_w}\sum_{n=1,3,5,\ldots}^{\infty}K'_n(nk_w a)I_n(nk_w r)\sin(\theta-k_w z), \qquad (1)$$

where I is the current flowing through the winding, λ_w is the period (pitch), $k_w \equiv 2\pi/\lambda_w$, (r, θ, z) are the cylindrical coordinates, and K_n and I_n are Bessel functions. From Eq. (1), the magnetic field components are found to be

$$\begin{cases} B_r = \dfrac{8Ik_w^2a}{c}\displaystyle\sum_{n=1,3,5,\cdots}^{\infty} K_n'(nk_wa)\cdot nI_n'(nk_wr)\sin n(\theta-k_wz), \\ B_\theta = \dfrac{8Ik_wa}{cr}\displaystyle\sum_{n=1,3,5,\cdots}^{\infty} K_n'(nk_wa)\cdot nI_n'(nk_wr)\cos n(\theta-k_wz), \\ B_z = -k_wr\cdot B_\theta \end{cases} \tag{2}$$

On the axis (r = 0), properties of the Bessel functions dictates that $I_1'(0) = 1/2$, $I_3'(0) = 0$, ... Therefore, only the first terms (n = 1) of the coefficients of B_r and B_θ are nonzeros. The n = 1 terms of B_r and B_θ are also the same. B_z is evidently zero at r = 0. We therefore have

$$\begin{cases} B_r|_{r=0} = B_w\sin(\theta-k_wz), \\ B_\theta|_{r=0} = B_w\cos(\theta-k_wz), \\ B_z|_{r=0} = 0, \end{cases} \tag{3}$$

where the magnitude of the magnetic field is

$$B_w = \frac{2}{5}\,k_wI\,[k_wak_0(k_wa)+k_1(k_wa)], \tag{4}$$

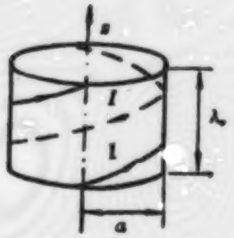

Figure 1. Schematic of a bifilar helix winding (I is the current, λ_w the pitch, a the radius)

In (4) the unit of I has been changed to Ampere and the unit of B_w is Gauss. Near the axis ($k_wr \ll 1$), we have

$$B_r \doteq B_w\sin(\theta-k_wz)+\alpha\cdot B_w\sin 3(\theta-k_wz), \tag{5}$$

$$B_\theta \doteq B_w\cos(\theta-k_wz)+\beta\cdot B_w\cos 3(\theta-k_wz), \tag{6}$$

where

$$\alpha = 3\cdot\frac{K_3'(3k_wa)}{K_1'(k_wa)}\cdot\frac{I_3'(3k_wr)}{I_1'(k_wr)} \doteq \frac{r^2}{a^2}, \tag{7}$$

$$\beta = 3\cdot\frac{K_3'(3k_wa)}{K_1'(k_wa)}\cdot\frac{I_3(3k_wr)}{I_1(k_wr)} \doteq \frac{r^2}{a^2}. \tag{8}$$

For actual computation equations (3)-(8) are too complex. We therefore use the approximate formula of Blewett[6]. For $a/\lambda_w > 0.2$ I is given by

$$I \doteq 0.246 \cdot \exp(5.68a/\lambda_w) \cdot \lambda_w \cdot B_w, \tag{9}$$

where the current I is in Amperes, the pitch λ_w is in centimeters, and the magnetic field B_w is in Gauss. We constructed our wiggler using copper wires with a circular cross-section. The dimensions are shown in Figure 2(a). The field intensity B_w is

$$B_w = \frac{8.13}{\pi} \cdot \frac{I}{\lambda_w r^2} \int_{a_1}^{a_2} \sqrt{r^2 - (r + a_1 - a)^2} \exp(-5.68a/\lambda_w) da, \tag{10}$$

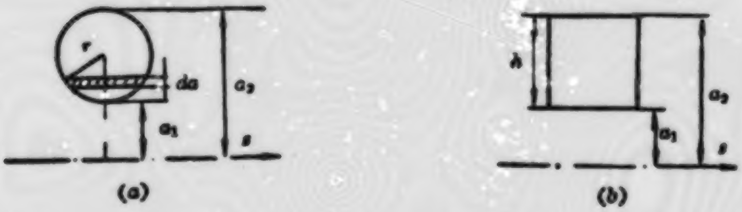

Figure 2. Schematic of finite-dimension wire used in making bifilar helix winding
(a) circular-section wire; (b) rectangular-section wire

Substituting the data for the straight section ($r = 0.2$ cm, $a_1 = 1.5$ cm, $\lambda_w = 2.2$ cm) into (1) and performing the numerical integration, we have

$$B_w = 0.0237I. \tag{10'}$$

As a comparison, the field intensity for a flat wire is

$$B_w = 0.716 \frac{I}{h} \left[\exp\left(-\frac{5.68}{\lambda_w} a_1 \right) - \exp\left(-\frac{5.68}{\lambda_w} a_2 \right) \right], \tag{11}$$

For a square wire (using the same, r, a_1 and λ_w), we have

$$B_w = 0.0240I, \tag{11'}$$

The difference is less than 1.3 percent. For the convenience of winding, we used wires with a circular cross-section. For a two-layer winding, $B_w = 0.0321$ I. For a three-layer winding, $B_w = 0.035$ I. The changes are small for more than three layers. The coil is driven by a conventional impulse current generator. Theoretical calculation shows that the peak current is $I_m \doteq 12.7\ u_o$ (u_o is the charging voltage) and the rise time is 0.5 msec. The relationship between the field intensity B_w and the charging voltage u_o is

$$B_w(\text{Gauss}) = 0.4u_0(\text{V}). \tag{12}$$

For a maximum B_w of 1 KG, the charging voltage is 2.5 kV.

Next we consider the pitch λ_w of the wiggler. Since the accelerator voltage of our electron pulse was somewhat too low (0.5 MeV), we had to carefully choose the parameters. We wish to control the laser wavelength in the millimeter range (<1 cm) while at the same time ensure that the wiggler field imparts enough transverse velocity to the electron beam so that the gain is higher than the threshold ($\beta_\perp \approx 0.2$, corresponding to the optimum gain region of the Jackson setup[1]). Based on the principle of free electron laser oscillation due to the cross-over of the pump shifted negative energy static beam mode and the electromagnetic dispersion curve, and taking into account the finite length of the waveguide, we derived the frequency of the laser radiation.

$$\omega = \gamma_z^2\left(k_w v_z - \frac{\omega_p}{\gamma_z}\right)\left[1 \pm \left\{\beta_z^2 - \frac{\beta_z^2 \omega_{c0}}{\left[\frac{\omega_p}{\gamma_z} - k_w v_z\right]^2 \cdot \gamma_z^2}\right\}^{1/2}\right], \tag{13}$$

where $\gamma_z = \frac{1}{\sqrt{1-\beta_z^2}}$, $\beta_z = \frac{v_z}{c}$, v_z is the axial velocity of the electron, c is the speed of light, $k_w = 2\pi/\lambda_w$, λ_w is the pitch of the wiggler, $\omega_p \equiv \sqrt{4\pi n e^2/\gamma_z m}$ is the plasma frequency of the electron beam in a coordinate system with a velocity v_z, n is the electron beam density, m is the mass of the electron beam, e is the electron charge and ω_{co} is the cutoff frequency. Simultaneously solving (13) and the transverse velocity $v_\perp$ given by the stable orbit theory (solving a set of transcendental equations), we have

$$v_\perp = \frac{\Omega_w v_z}{(\Omega_0 - \gamma_z v_z k_w)}, \tag{14}$$

where $\Omega_w \equiv eB_w/mc$, is the cyclotron frequency, $\Omega_0 = \frac{eB_0}{mc}, B_0$, and B_0 is the guiding magnetic field.

We obtained results on the effects of λ_w on the laser coupling frequency f_{TE} and the transverse velocity of the electron and the data are shown in Figure 3. The results show that the laser wavelength does not decrease as the wavelength of the wiggler field decreases. In fact, as shown in Figure 3, the laser wavelength increased as λ_w decreased for values of λ_w less than 2.25 cm. This is caused by an increase in the transverse velocity $\beta_\perp$ of the electron as the operating point approached the singular point of the magnetic cyclotron resonance. To obtain a small enough wiggler wavelength while maintaining a sufficiently large transverse velocity (large enough gain), an appropriate value of λ_w is 2.2 cm.

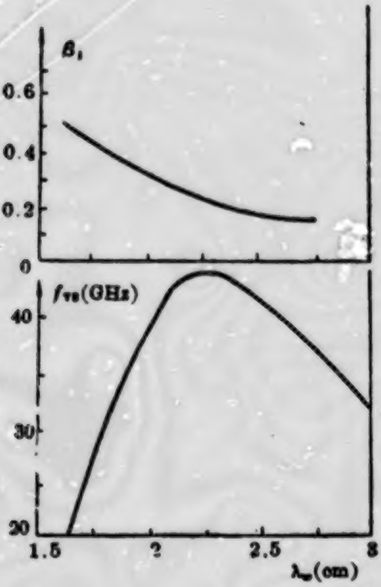

Figure 3. Calculated relationships between $\beta_\perp$ (transverse velocity of electrons) and wiggler period λ_w, and between f_{TE} (laser frequency of $TE_{\parallel}$ mode) and λ_w
Condition: relativistic factor $\gamma = 2$; beam current I = 1 kA; beam diameter 6 mm; drift tube diameter 20 mm; wiggler amplitude o.5 KG; guiding field 10 KG

III. Experimental Results

Figure 4 is a photograph of the bifilar helix wiggler. This wiggler has a pitch of 22 mm and the total length 572 mm contains 26 periods. It is wound on a nylon skeleton with 4 mm diameter cotton yarn covered copper wire in three layers. The central 14 periods are in the straight section and the minimum radius from the axis is 15 mm. In order to avoid perturbation of the electron beam as it enters and leaves the wiggler, the magnetic field at the entrance and exit of the wiggler should be changing gradually to ensure adiabaticity[7]. We made the 7 cycles at the entrance (154 mm, left hand end in Figure 4) and the 5 cycles at the exit (110 mm, right hand end in Figure 4) gradually deviating from the axis in the shape of a trumpet. The radius increased from 15 mm at the straight section to 28 mm at the mouths. From Eq. (9), the magnetic field at the exit will be 0.035 times that at the straight section.

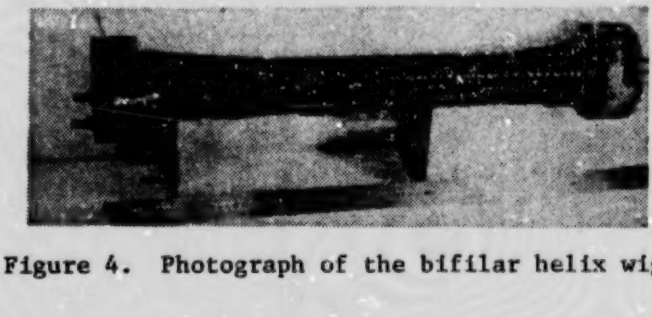

Figure 4. Photograph of the bifilar helix wiggler

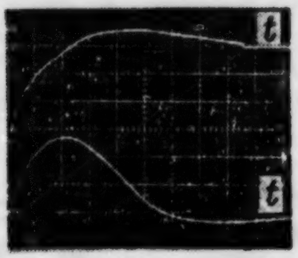

Figure 5. Wavefront of the wiggler field, time scale 0.2 ms/div; voltage scale 0.1 V/cm
Upper trace: dB_w/dt waveform; lower trace: B_w waveform; condition: capacitor voltage, 2 kV, corresponding to a peak value of wiggler field of 576 Gauss

The upper curve in Figure 5 shows the derivative (dB_w/dt) of the wiggler field measured along the axis by a small induction coil (325 turns, average diameter 3 mm). The signal is integrated in a home-made Miller integrator and the resulting waveform of B_w is shown as the lower curve in Figure 5. The peak value of the pulse is 576 Gauss and the rise time is 0.4 msec. The wiggler field as a function of the charging voltage of the capacitor is shown in Figure 6. As can be seen, the experimental value is smaller than the theoretical value by about 25 percent. We believe the discrepancy is mainly caused by errors in the computed ICR circuit parameters and by the finite size of the small test coil.

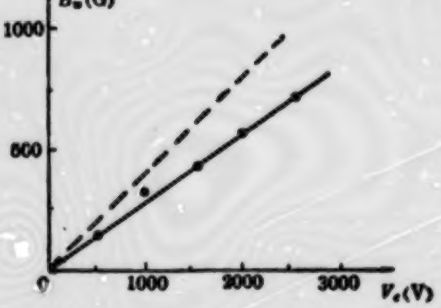

Figure 6. Wiggler field B_w vs. capacitor voltage V
Dash line: calculated from Eq. (12);
Dots: measured value

Figure 7 shows the measured wiggler field versus the axial position of a test coil moved along the axis while maintaining a fixed angle θ. The results show that the wiggler field is indeed right-circularly polarized, with a period of 22 mm and the positive peak and the negative peak differ by less than 5 percent. The magnetic field in the straight section fluctuates within 10 percent. Measurements also show that the magnetic field of the adiabatic tapering at the mouths gradually decreases from the value at the straight section to approximately zero at the openings.

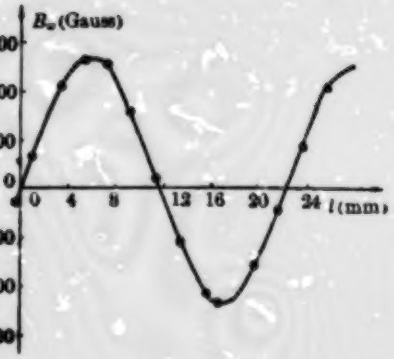

Figure 7. Measured values of the bifilar-helix wiggler along the axial direction (l)
Condition: capacitor voltage 1 kV; probe coil 325 turns with average diameter of 2 mm

Using the bifilar helix wiggler and a guidance magnetic field, we pumped a solid cylindrical electron beam and obtained free electron laser output[4] (coherent superradiation amplification mode) under an appropriate parameter combination. The experimental results are shown in Figure 8. The operating parameters are: electron beam energy 0.5 MeV (as measured by the voltage of the electron gun diode), electron beam current 0.2 kA (as measured by the Faraday cup at the end of the drift tube), electron beam persistence time 60 ns, and the electron beam diameter at the end of the 1 meter long drift tube is 6 mm (as measured from beam bombardment). The inner diameter of the drift tube is 20 mm, the radiation is coupled out via the horns with 13 dB gain, and is received by the H surface horn. The radiation is fed into a shielded room via 3 m long K_a band standard waveguide for temporal and frequency spectral measurement. The laser energy is measured with a carbon calorimeter.

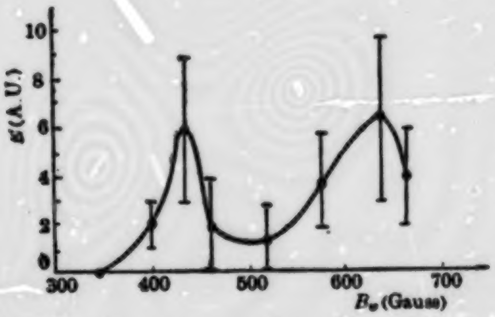

Figure 8. Output laser energy vs. wiggler field B_w, for solid cylindrical e-beam pumped by the bifilar-helix wiggler
The guiding field: 10 KG

Figure 8 shows that the radiation is strong only in the 400-650 Gauss region of the wiggler. This is consistent with the observations made at the United States Naval Research Laboratory[1]. The reason is that, for a given steering magnetic field, the region of large laser gain corresponds to the upper and lower limits of the transverse velocity $\beta_\perp$ of the electron, which in turn corresponds to the upper and lower limits of the wiggler field.

Typical parameters of the laser radiation are: 8 mm wavelength (K_a band), 20 ns pulse width, 2 mJ energy, 0.1 MW average power, and 0.1 percent efficiency. These parameters are similar to the results obtained with an iron ring wiggler[4]. This result is still about two orders of magnitude below the performance of similar devices abroad. Improvements will be made in further optimization of the experiment.

This work was conducted under the supervision of Professor Wang Zhijiang. Wang Yunfang and Pan Hua of the Shanghai Institute helped the coil winding, and Shi Jinchuan and Feng Bingfang participated in some of the experiments. The authors also thank Yan Yumin (1985 graduate of the Changchun College of Optics of Fine Mechanics) for extensive preparatory work.

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9698/6091
CSO: 4008/1

APPLIED SCIENCES

BRIEFS

THEORY ON PLATE TECTONICS INTRODUCED--Beijing, 23 Oct (XINHUA)--Chinese scientists believe the earth's crustal movements began somewhere between 1.8 billion and 1.4 billion years ago, and not the 160 million years as generally accepted in the world. Two geologists from Nanjing University say plate movements of the earth's crust occurred as far back as 1.8 billion years ago in the moving continental margin of southeast China and the east Qinling Mountains in northwest China, GUANGMING DAILY has reported. Professors Guo Lingzhi and Shi Yangshen say their conclusion is well supported by ample geochemistry and geophysics data and it is important to the prospecting of energy and mineral resources in the western Pacific. According to the plate tectonics theory of geology, the earth's crust is divided into six major plates moving in relation to each other, thus explaining the shifting of the ocean floor, continental drift, and mountain-building. The Nanjing University professors presented their theory at an international geological symposium Monday in Nanjing, capital of east China's Jiangsu Province. [Text] [Beijing XINHUA in English 0213 GMT 23 Oct 86 OW]

EARTHQUAKE PREDICTION URGED--Beijing, 18 Oct (XINHUA)--Earthquakes which have occurred in China over the past 37 years killed 270,000 people and injured 230,000, a government official disclosed here today. Director of the state Seismological Bureau An Qiyuan said the emphasis of seismological research work should be placed on the forecasting of earthquakes. Since the quake (6.7 magnitude on the Richter scale) in Xingtai, Hebei Province, in 1964, the bureau and its local branches have considered the reduction of the damage from earthquakes as their main task, An said. "Thus, we successfully forecast the earthquake (7.3 magnitude on the Richter scale) in Haicheng, in northeast China's Liaoning Province in 1975, saving probably 100,000 lives," An said, adding that that was the first effective forecast in the history of seismological science in the world. However, the bureau failed to forecast the Tangshan quake (7.8 magnitude, killing 240,000 and injuring 160,000), he lamented. Both the successes and failures have all demonstrated the importance of forecasting work, An said. [Text] [Beijing XINHUA in English 1613 GMT 18 Oct 86 OW]

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CSO: 4010/10

SCIENTISTS AND SCIENTIFIC ORGANIZATIONS

BRIEFS

SHANGHAI ELECTRONIC RESEARCH CENTER--Beijing, 12 September (XINHUA)--An electronic research center passed an operational check on Thursday in Shanghai. Built by Fudan University, the center will engage in analysing and testing imported electronic equipment. [Text] [Beijing XINHUA in English 1058 GMT 12 Sep 86 OW] /12232

S&T UNIVERSITY MICROCOMPUTER COURSE--Hefei, 22 September (XINHUA)--A microcomputer training course for developing Asian countries opened today at the Chinese University of Science and Technology in Hefei, capital of east China's Anhui Province. The course is run jointly by the Italian International Center for theoretical physics under UNESCO and the Chinese Academy of Sciences. During the 1-month course, 24 experts from Italy, Switzerland and the United States will teach 80 students from 11 Asian countries. The first such microcomputer course was run in Sri Lanka in 1984. [Text] [Beijing XINHUA in English 1628 GMT 22 Sep 86 OW] /12232

CSO: 4010/1005

ION EXCHANGE OF URANIUM DISTRIBUTION OF URANIUM (IV) BETWEEN STRONG-BASE ANION-EXCHANGE RESIN AND SOLUTIONS OF HCl WITH ORGANIC SOLVENT

Lanzhou LANZHOU DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF LANZHOU UNIVERSITY (NATURAL SCIENCE EDITION)] in Chinese Vol 22 No 2, 28 Jun 86 pp 53-59

[English abstract of article by Guo Hongyun [6753 4767 0061], et al.]

[Text] The distribution of U (IV) between a strong-base anion exchange resin and solutions of HCl with organic solvent has been studied. Using visible spectroscopy the authors studied the uranium (IV) species sorbed on an anion exchanger and the species which had been in the mixed solvents. The results of these investigations show that the distribution ratio of U (IV) increases obviously in the presence of ethanol and acetone, and the predominant uranium (IV) species sorbed on the anion resin is still UCl_6^{2-}. (Paper received 24 September 1984.)

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9717
CSO: 4009/1016

Applied Mathematics

DEFINING NONDETERMINISM IN SPACE BOUNDED TURING MACHINES

Lanzhou LANZHOU DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF LANZHOU UNIVERSITY (NATURAL SCIENCE EDITION)] in Chinese Vol 22 No 2, 28 Jun 86 pp 10-14

[English abstract of article by Li Lian [2621 1670]]

[Text] The nondeterministic complexity of a Turing machine T is defined to be the number of the nondeterministic moves made by T. It is, in general, a function of the length of input. In this paper, we discuss the hierarchy problems with respect to the nondeterministic complexity and their relativization problems. In particular, it is proven that there exists an Oracle set E so that, in respect to E, there is an infinite hierarchy based on the nondeterministic complexity. (Paper received 25 January 1985.)

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Applied Mathematics

PERTURBATION-VARIATIONAL SOLUTION OF LARGE DEFLECTION OF RECTANGULAR PLATES UNDER UNIFORM LOAD

Chongqing YINGYONG SHUXUE HE LIXUE [APPLIED MATHEMATICS AND MECHANICS] in Chinese Vol 7 No 8, Aug 86 pp 675-688

[English abstract of article by Pan Lizhou [3382 4539 1352], et al., of Shanghai Institute of Applied Mathematics and Mechanics, Shanghai]

[Text] In this paper, von Karman's set of nonlinear equations for large deflection of rectangular plates is at first converted into several sets of linear equations by taking the central dimensionless deflection as the perturbation parameter, and then the sets of linear equations for plates with various ratios of length to width are solved with application of the variational method. The analytical expressions for displacements and stresses as well as formulas for numerical calculations are worked out. The figures for the maximum deflection-load and maximum stress, with a ratio λ of length to width as a parameter, are given in this paper. Through comparison, it is found that the results of this paper are in good accord with those of experiments. (Paper received 1 June 1985.)

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CHAPLYGIN EQUATION IN THREE-DIMENSIONAL NON-CONSTANT ISENTROPIC FLOW--THE THEORY OF FUNCTIONS OF COMPLEX VARIABLE UNDER DIRAC-PAULI REPRESENTATION AND ITS APPLICATION IN FLUID DYNAMICS (III)

Chongqing YINGYONG SHUXUE HE LIXUE [APPLIED MATHEMATICS AND MECHANICS] in Chinese Vol 7 No 8, Aug 86 pp 703-712

[English abstract of article by Shen Huichuan [3088 1920 1557] of the Department of Earth and Space Sciences, University of Science and Technology of China, Hefei]

[Text] This work is the continuation of the discussion presented in reference [1]. In this paper the author resolves the equations of isentropic gas dynamics into two problems: the three-dimensional non-constant irrotational flow (therefore, the isentropic flow, too), and the three-dimensional non-constant indivergent flow (i.e., the incompressible isentropic flow). The theory of functions of a complex variable under Dirac-Pauli representation and the Legendre transformation are applied, thus transforming these equations from two problems from physical space into velocity space, and obtaining two general Chaplygin equations. The general Chaplygin equation is a linear difference equation and its general solution can be expressed at most by the hypergeometric functions. Therefore, we can obtain the general solution of general problems for the three-dimensional non-constant isentropic flow of gas dynamics. (Paper received 1 May 1985.)

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ON THE PROBLEM OF PREVENTING BLOWING-UP AND QUENCHING FOR SEMILINEAR HEAT EQUATION

Chongqing YINGYONG SHUXUE HE LIXUE [APPLIED MATHEMATICS AND MECHANICS]
in Chinese Vol 7 No 8, Aug 86 pp 713-718

[English abstract of article by Yan Ziqian [0917 1311 6197] of the Department of Mathematics, Jilin University, Jilin]

[Text] In this paper, the global existence of solutions to the IVP

$$u_t = \Delta u + g(t)f(u) \quad (t > 0, u|_{t=0} = u_0(x)$$

and the IBVP

$$u_t = \Delta u + g(t,x)f(u) \quad (t > 0, x(\Omega), u|_{t=0} = u|_{\partial\Omega} = 0$$

is investigated. As was done in Reference [6], the introduction of factors $g(t)$ or $g(t,x)$ in the nonlinear term is to prevent the occurrence of blowing-up or quenching of solutions. It is shown in this paper that most of the restrictions on f, g and u_0 in the theorems contained in Reference [6] may be cancelled or relaxed, that the smallness of g is required only for large t, and that under certain conditions, controlling the initial state can prevent the blowing-up. (Paper received 3 May 1983.)

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FEEDBACK TRACKING SYSTEM FOR ROBOT

Chongqing YINGYONG SHUXUE HE LIXUE [APPLIED MATHEMATICS AND MECHANICS]
in Chinese Vol 7 No 8, Aug 86 pp 719-727

[English abstract of article by Zhang Hongtao [1728 3183 3447], et al., of the Department of Mechanics, Beijing University, Beijing]

[Text] The feedback information necessary for tracking is specified for a class of systems including robots. A feedback control method is proposed by which a robot can track and grasp an arbitrarily moving object in space. It differs from other methods in that it remains effective when it is impossible to know the orientation of the claw in advance. Its validity is verified by digital simulation. (Paper received 29 May 1985.)

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THERMAL BENDING OF THICK RECTANGULAR PLATES OF BIMODULUS COMPOSITE MATERIALS

Chongqing YINGYONG SHUXUE HE LIXUE [APPLIED MATHEMATICS AND MECHANICS]
in Chinese Vol 7 No 8, Aug 86 pp 739-745

[English abstract of article by Bai Zongfang [4101 1350 2455], et al., of Qingdao Chemical Engineering Institute, Qingdao]

[Text] Weighted residual solutions are presented for thermal bending of laminated composite plates. The material of each layer is assumed to be elastically and thermoelastically orthotropic and bimodular. The formulations are based on the thermoelastic version of the theory of the Whitney-Pagano laminated plate, which includes thickness shear deformations. The results are obtained for deflections and neutral-surface positions, and are found to be in good agreement with the closed-form solution. (Paper received 3 October 1985.)

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RESEARCH ON VISCO-ELASTIC TYPE II RUPTURE WITH EXCITING AND ATTENUATION PROCESS

Chongqing YINGYONG SHUXUE HE LIXUE [APPLIED MATHEMATICS AND MECHANICS]
in Chinese Vol 7 No 8, Aug 86 pp 759-767

[English abstract of article by Fan Jashen [5400 1367 0639] of Yunnan Institute of Technology, Kunming]

[Text] With the nonlinear Rayleigh damping formula, the author describes the exciting process when the rupture velocity is low and the attenuation process when the rupture velocity reaches a certain high value. Assuming the medium of the earth's crust is homogeneous and an isotropic linear Voigt visco-elastic body, the small parameter perturbation method is used to form a system of asymptotic linear equations from non-linear governing partial differential equations. These are solved by means of a generalized Fourier series with moving coordinates as its variables, thus transforming them into non-homogeneous Mathieu equations. The Mathieu equations are then solved by the WKBJ method. (Paper received 31 October 1983.)

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9717
CSO: 4009/1014

ACCURATE DETERMINATION OF SMALL VARIATIONS FOR PARAMETERS OF POSITRON LIFETIME SPECTRA IN AMORPHOUS ALLOY

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 5, Sep 86 pp 513-518

[English abstract of article by Xiong Liangyue [3574 5328 6885] of the Institute of Metal Research, Chinese Academy of Sciences]

[Text] A method for the accurate determination of the small variation in positron lifetime spectrum parameters is described using the example which determines the positron lifetime variations by means of annealing in amorphous material. A comparison between the differential distributions by simulation calculation and experimental measurement confirms that the mean positron lifetimes in metallic glass $Fe_{67}Co_{18}Si_{1}B_{14}$ after annealing at 100°C, 300°C and 375°C are 0 ps, 4.0 ps and 4.3 ps respectively, shorter than those in the nontreated reference sample.

PLASTIC SCINTILLATOR RESPONSE TO CHARGED PARTICLES

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 5, Sep 86 pp 519-526

[English abstract of article by Zhou Dazhuang [0719 1129 8369] of the University of Science and Technology of China]

[Text] Plastic scintillators have many advantages and are widely used in particle physics. Research on plastic scintillator responses at both high energy and high electric charges is significant in experiments in high energy physics and cosmic ray physics. In addition to many important astrophysical results, the high energy cosmic ray experiments at the University of Chicago accumulate data for plastic scintillator responses to relativistic particles of high electric charges. This paper introduces the cosmic ray experiments mentioned above, presents data analysis results and discusses the nonlinear response of plastic scintillators.

BEHAVIOR OF PARTONS OF LARGE TRANSVERSE MOMENTUM IN DEEP INELASTIC SCATTERING

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 5, Sep 86 pp 536-544

[English abstract of article by Wang Zhengben [3769 2973 2609] of Yunnan University]

[Text] The nucleonic states are represented by different configuration components in Fock space and the transverse momentum of partons is introduced as a degree of freedom into the structure function. In this way the author calculated the contribution of the components of the valent quarks and the non-valent quarks of the charm state to the ratio of the longitudinal and transverse cross sections of the virtual photons. An improved agreement with the experimental data is obtained. The causes of deviation of the Callan-Gross relation from the experimental data are pointed out.

POSSIBLE FORM OF PION'S STRUCTURE FUNCTION

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 5, Sep 86 pp 562-569

[English abstract of article by Long Ming [7893 7686] and Huang Tao [7806 3447] of the Institute of High Energy Physics, Chinese Academy of Sciences]

[Text] The pion's structure function behavior is discussed using the Fock state expansion of the hadronic wavefunction in QCD in this paper. As an example, the authors employ a model wavefunction of the Fock state in the light-cone and assume a Regge behavior of a weight function for high Fock states, obtaining a possible form of the pion's structure function. This form is consistent with experimental data of the pion's structure function.

EDDY-CURRENT EFFECTS OF BENDING MAGNET ON ELECTRON STORAGE RING DURING SLOW ACCELERATION

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 5, Sep 86 pp 578-582

[English abstract of article by Zhang Wu [1728 2976], et al., of the University of Science and Technology of China; and Xu Jianming [1776 1696 6900] of the Institute of High Energy Physics, Chinese Academy of Sciences]

[Text] The magnetic field distribution of a C-type solid yoke bending magnet, a model magnet used on the Hefei synchrotron, is measured, and the eddy-current effects of a bending magnet on an electron storage ring during slow acceleration are investigated by a two coil induction approach. When slow acceleration exists, the possibility of applying a solid yoke bending magnet is verified.

APPROACH TO STRUCTURE FUNCTION FOR NUCLEON

Beijing GAONENG WULI YU HE WULI [PHYSICA ENERGIAE FORTIS ET PHYSICA NUCLEARIS] in Chinese Vol 10 No 5, Sep 86 pp 632-635

[English abstract of article by Long Ming [7893 7686] of the Institute of High Energy Physics, Chinese Academy of Sciences]

[Text] The structure function for the nucleon is discussed using the method given in a previous paper. The formulas are compared with the experimental data from low Q^2 to high Q^2. The results show that the way the structure function for the nucleon is obtained from the hadronic wavefunction is a possible approach to investigating structure functions for the hadron.

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CATALYTIC BEHAVIOR OF FERRIC COMPOUNDS IN OXIDATIVE DEHYDROGENATION OF BUTENE TO BUTADIENE

Changchun YINGYONG HUAXUE [CHINESE JOURNAL OF APPLIED CHEMISTRY] in Chinese Vol 3 No 3, Jun 86 pp 8-12

[English abstract of article by Zhang Xiankuan [1728 2009 1401], et al., of Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences]

[Text] Five ferric compounds, α-Fe_2O_3, γ-Fe_2O_4, $ZnFe_2O_4$, $ZnFe_2O_4 \cdot 20$ percent α-Fe_2O_3 and $ZnFe_2O_4 \cdot 20$ percent γ-Fe_2O_3, used as catalysts for oxidative dehydrogenation of butene to butadiene, were prepared and identified by X-ray diffraction. The catalytic sites on the ferrite surface were studied by chemisorption and TPD of oxygen and n-butene. It was found that $ZnFe_2O_4$ adsorbed more butene than did α- and γ-Fe_2O_3, with the latter two oxides adsorbing more oxygen than the former compound, and the mixtures of the Fe_2O_3 isomers had greater ability for chemisorption of both butene and oxygen.

The reaction mechanism is discussed based on the different behaviors of these five ferric compounds acting as sorbents and oxygen-carriers in oxydative dehydrogenation of butene to butadiene or carbon dioxide. (Paper received 15 April 1985; finalized 11 November 1985.)

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SYNTHESIS AND CHARACTERIZATION OF POLYDIMETHYLSILOXANE-POLYPHENOLPHTHALEIN TEREPHTHALATE BLOCK COPOLYMER

Changchun YINGYONG HUAXUE [CHINESE JOURNAL OF APPLIED CHEMISTRY] in Chinese
Vol 3 No 3, Jun 86 pp 19-24

[English abstract of article by Sun Ji [1327 7535], et al., of Changchun Institute of Applied Chemistry, Chinese Academy of Sciences]

[Text] A series of polydimethylsiloxane-polyphenolphthalein terephthalate multi-block copolymers has been synthesized by using the low temperature solution condensation technique. The structural characterization of the block copolymers by IR, ^{1}H-NMR, viscosimetry, TEM, etc., indicates that copolymers with controlled siloxane content can be obtained in high molecular weights. The copolymers can be either elastomeric or rigid, depending on the siloxane block length and its content. The copolymers show two-phase morphology, good mechanical properties, thermostability and film formability. (Paper received 24 April 1985; finalized 30 November 1985.)

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SURFACE CHARACTERISTICS OF γ-Fe_2O_3 POWDER

Changchun YINGYONG HUAXUE [CHINESE JOURNAL OF APPLIED CHEMISTRY] in Chinese
Vol 3 No 3, Jun 86 pp 30-34

[English abstract of article by Jin Shijiu [6855 1102 0046], et al., of the Institute of Chemistry, Chinese Academy of Sciences]

[Text] Dispersion of γ-Fe_2O_3 powder in a polymer solution plays in important role in governing the recording density of magnetic recording materials. The wetting of the powders, disintegration of agglomerates and agglutination of particles are closely related to the surface characteristics of the γ-Fe_2O_3 powder. In this paper, the wetting characteristics and apparent contact angles of the γ-Fe_2O_3 powder in polar and non-polar liquids have been estimated by determining the penetration rates of these liquids through powders, as well as the sedimentative volume of powders in liquids. Based on Fowkes' theoretical assumption, the values of the surface tension of γ-Fe_2O_3 powder have been calculated: $\gamma_s^d = 24$ dyn/cm, $\gamma_s^p = 17$ dyn/cm and $\gamma_s = 41$ dyn/cm. (Paper received 28 April 1985; finalized 4 September 1985.)

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ON THE MECHANISM OF THE REACTION BETWEEN VINYL ACETATE AND POLYBUTADIENYL-LITHIUM

Changchun YINGYONG HUAXUE [CHINESE JOURNAL OF APPLIED CHEMISTRY] in Chinese
Vol 3 No 3, Jun 86 pp 35-39

[English abstract of article by Shen Changjiang [3947 7022 3068], et al., of Beijing Institute of Chemical Technology]

[Text] The mechanism of the reaction between acetate and polybutadienyl-lithium was studied by using naphthalenelithium as the initiator in extracted naphtha solution. It was found that a coupling reaction occurs after vinyl acetate nad polybutadienyl-lithium have been brought together in an evacuated vessel accompanied by a simultaneous introduction of hydroxyl groups into the polymer chain. (Paper received 9 March 1985; finalized 10 May 1985.)

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INFLUENCE OF HIGH-LOW JUNCTION IN EPITAXIAL p-Si ON PHOTOELECTRICAL CONVERSION EFFICIENCY

Changchun YINGYONG HUAXUE [CHINESE JOURNAL OF APPLIED CHEMISTRY] in Chinese
Vol 3 No 3, Jun 86 pp 56-60

[English abstract of article by Li Cheng [2621 3397], et al., of the Department of Chemistry, Shandong University]

[Text] An epitaxial p-Si(p^+/p-Si) containing a semiconductive high-low junction was used as the photocathode in both photoelectrochemical voltaic and photo-assisted hydrogen evolution cells. The conversion efficiencies were 7.4 percent ($V^{2+/3+}$ redox couple) and 7.8 percent (Co-W alloy decorated) respectively. The role of high-low junction in improving conversion efficiency is discussed. (Paper received 5 January 1985; finalized 26 February 1985.)

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STUDIES ON EXTRACTION KINETICS. V. EXTRACTION OF COBALT (II) WITH HDEHP BY SINGLE DROP METHOD

Changchun YINGYONG HUAXUE [CHINESE JOURNAL OF APPLIED CHEMISTRY] in Chinese
Vol 3 No 3, Jun 86 pp 61-66

[English abstract of article by Gai Huifa [5556 2585 3127], et al., of the Department of Chemistry, Shandong University, Jinan]

[Text] The kinetics and mechanism of the extraction of Co(II) from a sulphate solution with HDEHP in kerosene have been studied by means of the single drop method at 25°C. The experimental results indicate that the extraction process in controlled by the following interface reactions:

$$Co^{++} + 2HA_{(i)} = CoA_{2(i)} + 2H^{+}$$

$$CoA_{2(i)} + 2H_2A_{2(o)} = CoA_2 \cdot 2HA_{(o)} + 2HA_{(i)}$$

where (o) and (i) represent organic phase and interface respectively. The influences of sulphate, chloride and nitrate concentration on the extraction rate are also discussed. (Paper received 12 March 1985; finalized 24 August 1985.)

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HIGH DAMPING BUTYL RUBBER FOR VIBRATION CONTROL

Changchun YINGYONG HUAXUE [CHINESE JOURNAL OF APPLIED CHEMISTRY] in Chinese
Vol 3 No 3, Jun 86 pp 67-69

[English abstract of article by Liu Jingjiang [0491 2529 3068], et al., of Changchun Institute of Applied Chemistry, Chinese Academy of Sciences]

[Text] ADR-06010 and ADR-06011 damping materials, unfilled and filled butyl rubber, have an inherently high damping capacity. Metal structures with these damping materials show excellent efficiency in vibration control. The results show that the bushings of ADR-06010 and ADR-06011 damping rubber have good isolation behavior. (Paper received 14 March 1985; finalized 15 January 1986.)

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INHIBITION EFFECT OF VANADIUM ON CARBON DEPOSITION ON ANTIMONY-IRON OXIDE CATALYSTS DURING AMMOXIDATION

Changchun YINGYONG HUAXUE [CHINESE JOURNAL OF APPLIED CHEMISTRY] in Chinese Vol 3 No 3, Jun 86 pp 70-72

[English abstract of article by Li Guijia [2621 0964 3946], et al., of Changchun Institute of Applied Chemistry, Chinese Academy of Sciences]

[Text] The ammoxidation of propylene using an antimony-iron oxide catalyst was investigated by means of a fluidized bed reactor. The reactivity, amount of carbon deposited, and ESR spectrum data have been determined. The results indicate that a vanadium doped system resists the carbon deposition, stabilizing the structure of the catalysts, and accelerates the reoxidation rate of the reduced catalysts. (Paper received 15 May 1985; finalized 13 January 1986.)

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SYNTHESIS OF PHENYL NEODYMIUM (II) CHLORIDE AND ITS CATALYTIC ACTIVITY FOR DIENE POLYMERIZATION

Changchun YINGYONG HUAXUE [CHINESE JOURNAL OF APPLIED CHEMISTRY] in Chinese Vol 3 No 3, Jun 86 pp 73-75

[English abstract of article by Qi Shuzhen [7871 3219 3791], et al., of Changchun Institute of Applied Chemistry, Chinese Academy of Sciences]

[Text] In this paper, the reaction of Nd metal vapor produced at high temperatures under a vacuum below 10^{-4} mm Hg with chlorobenzene at -196°C, giving phenyl neodymium chloride, has been preliminarily investigated. The composition of the product has been identified as C_6H_5NdCl by chemical analysis. The compound is a black crystalline, insoluble in organic solvents, stable at room temperature, extremely air-moisture sensitive, and pyrophoric in air.

The complex combined with $Al(i\text{-}Bu)_2H$ is able to polymerize diene to polybutadiene with cis-1,4 contents of 94.4 percent, trans-1,4 4.7 percent, 1.2 - 0.9 percent, and polyisoprene with cis-1,4 contents of 94.4 percent and 3,4- of 5.6 percent. (Paper received 24 April 1985; finalized 21 November 1985.)

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UNUSUAL BEHAVIOR OF POLYETHYLENE TEREPHTHALATE IN CRYSTALLIZATION

Changchun YINGYONG HUAXUE [CHINESE JOURNAL OF APPLIED CHEMISTRY] in Chinese
Vol 3 No 3, Jun 86 pp 79-80

[English abstract of article by Ma Ruisen [7456 3843 3947], et al., of the Institute of Material Science, Fudan University]

[Text] Spherulite growth rates and morphological structure changes during the crystallization of PET have been investigated using depolarimetry, polarized microscopy (PLM) and small angle light scattering (SALS).

The unusual behavior of spherulite growth rate curves under various conditions in the crystallization of PET have been observed by depolarimetry. A plot of depolarized light versus crystallization time indicates that there is a slight reduction in the crystallinity at higher temperatures. It is suggested for this phenomenon that partial melting and recrystallization of the crystalline occure at higher temperatures. In other words, imperfect crystallites are melted and changed into more perfect forms (better crystal lattice, larger crystal size). Observations with PLM confirm the suggested explanation.

Three types of spherulite patterns (usual, unusual and complex) in PET under different crystallization temperatures have been observed with PLM. The usual spherulites are formed at lower temperatures, while unusual spherulites are formed at higher temperatures. The results agree with Hv patterns of SALS. (Paper received 29 July 1985; finalized 28 November 1985.)

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INTERCONNECTION STRUCTURE FOR DATA FLOW COMPUTERS

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 23 No 9, Sep 86 pp 2-10

[English abstract of article by Chen Guoliang [7115 0948 5328] of the University of Science and Technology of China]

[Text] In order to exploit the parallelism of data flow computers, software engineers must analyze the data-dependency expression as a one-dimensional program segment and translate it into a two-dimensional flow graph which can be easily executed in parallel. In addition, the architects must design a system structure which is suitable for executing a two-dimensional program graph and includes the architecture organization principle and packet communication structure suitable for asynchronous operation features. In this paper, from the point of view of an interconnection structure for data flow computers, the author studies the system organization principle of current data flow computers, discusses packet communication architecture suitable for data-driven operation features, and makes a case study of packet switch interconnection networks. Also, an evaluation is presented of various interconnection networks which can possibly be used by data flow computers. (Paper received in May 1985.)

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QUERY PROCESSING OF RELATIONAL MICRO-DBMS WITH MULTI-OPTIMIZATION

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT]
in Chinese Vol 23 No 9, Sep 86 pp 24-30

[English abstract of article by Wang Nengbin [3769 5174 2430] and Zhu Qiang [2612 1730] of Nanjing Institute of Technology]

[Text] Some problems emerging from the design and implementation of the query-processing subsystem (QPSS) of the relational micro-DBMS NITDB are presented and analyzed in this paper. A query processing method with multi-optimization suitable especially for microcomputers is suggested. In addition to a brief introduction to the process of the query processing in the system, optimization through query transformation, optimization through preprocessing qualification and optimization through access strategy selection are discussed. Moreover, null value processing, view processing and some other problems are briefly discussed as well, and a number of implementation techniques are presented. The authors' views on query processing in the environment of microcomputers are also given. (Paper received in July 1985.)

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MULTI-QUICK SORT

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 23 No 9, Sep 86 pp 44-50, 34

[English abstract of article by Pan Si [3382 1835] and Jin Zhiquan [6855 1807 2938] of the Department of Computer Science, Nanjing University]

[Text] The average running time of the quick sort is less than that of all other currently known 0 (nlogn) sorting algorithms. Its average time is 0 (nlogn), and its performance is 0 (n^2) in the worst case. The algorithm presented in this paper takes 0 (nlogm) to sort n elements, here m $\in$(1,[n/2]), and its performance is 0 (n) in the optimal case. The running results on the M-16 microcomputer are in agreement with the algorithm analysis given in the paper. (Paper received in September 1985.)

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DESIGN AND IMPLEMENTATION OF ACCESS METHOD LAYER OF NITDB

Nanjing NANJING GONGXUEYUAN XUEBAO [JOURNAL OF NANJING INSTITUTE OF TECHNOLOGY] in Chinese Vol 16 No 5, 20 Sep 86 pp 37-43

[English abstract of article by Wang Nengbin [3769 5174 2430], et al., of the Department of Computer Science and Engineering]

[Text] The design and implementation of the access method layer of NITDB, a multiuser relational DBMS being developed at Nanjing Institute of Technology, are presented. In NITDB, four types of storage structures are currently available: (1) sequential file structure, (2) clustering index sequential file structure, (3) secondary index file structure, and (4) index file structure especially designed for joining operatings. In addition to the implementation techniques, the philosophy behind the design and implementation of each type of storage structure is also described in some detail. (Paper received 11 October 1985.)

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SOME THEOREMS RELATING TO THE EQUIVALENCE OF MICRO SQL QUERY STATEMENTS AND OPTIMIZATION VIA QUERY TRANSFORMATION

Nanjing NANJING GONGXUEYUAN XUEBAO [JOURNAL OF NANJING INSTITUTE OF TECHNOLOGY] in Chinese Vol 16 No 5, 20 Sep 86 pp 44-53

[English abstract of article by Wang Nengbin [3769 5174 2430], et al., of the Department of Computer Science and Engineering]

[Text] Micro SQL is a data language used in NITDB, a relational DBMS on a microcomputer. In order to optimize queries, some theorems relating to the equivalence of Micro SQL query statements are given in this paper by extending the idea presented in Kim's paper. Some of the results have been used in NITDB and an optimization strategy via query transformation was developed in NITDB to make query processing more efficient. (Paper received 1 July 1985.)

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DEPLETION MODE MOSFET MODEL FOR SPICE II PROGRAM

Nanjing NANJING GONGXUEYUAN XUEBAO [JOURNAL OF NANJING INSTITUTE OF TECHNOLOGY] in Chinese Vol 16 No 5, 20 Sep 86 pp 54-61

[English abstract of article by Wei Tongli [7614 0681 4539], et al., of the Department of Electronic Engineering]

[Text] This paper analyzes the limitation cause of the SPICE II program used to simulate the characteristics of the depletion mode MOSFET and describes the characteristics of the depletion mode device in saturated and linear regions by using the saturated threshold voltage and linear threshold voltage. The paper also discusses the difference between the saturated and linear threshold voltage versus the back bias voltage, and presents a model of the depletion mode MOS transistor and a new parameter extraction method. The simulation results are in good agreement with the experimental data. (Paper received 18 October 1985.)

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APPLICATION OF MICROCOMPUTER DATABASE TO MANAGEMENT SYSTEM OF INSTRUMENTS AND APPARATUS IN INSTITUTIONS OF HIGHER LEARNING

Nanjing NANJING GONGXUEYUAN XUEBAO [JOURNAL OF NANJING INSTITUTE OF TECHNOLOGY] in Chinese Vol 16 No 5, 20 Sep 86 pp 135-138

[English abstract of article by Zhao Zhongxuan [6392 0112 1357], et al., of the Research Institute of Automation, Nanjing Institute of Technology]

[Text] A new generation of databases--DBASE III -- is introduced by means of which a computer management system of instruments and apparatus has been developed. It possesses higher efficiency and stronger functions. This paper gives a technical illustration of the management system and an introduction to five functional modules and submodules which form the management system. (Paper received 10 October 1985.)

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KINETICS OF TYPE II PNEUMOCYTES AND ALVEOLAR MACROPHAGES IN EXPERIMENTAL SILICOSIS

Beijing ZHONGHUA JIEHE HE HUXIXI JIBING ZAZHI [CHINESE JOURNAL OF TUBERCULOSIS AND RESPIRATORY DISEASES] in Chinese Vol 9 No 3, 12 Jun 86 pp 129-132, 188

[English abstract of article by Si Turui [0674 1778 6904], et al., of Jinan University, Guangzhou]

[Text] The silicotic nodules of 50 rabbits' lungs were observed by electron microscopy after intratracheal instillation with 120 mg silica crystals per kg at days 2, 7, 15, 45, 90, 180, 250 and 360. The following observations were recorded:

Throughout the experimental process, neutrophils, type II pneumocytes, alveolar macrophages, monocytoids, fibroblasts, plasmacytes and lymphocytes were found in the silicotic nodules. During the formation of silicotic nodules, the cellular types not only changed continuously, but also depended on one another for their existence.

Tissue chopper of 16 rat lungs was evaluated by cytologic studies after intratracheal instillation with 40 mg of silica crystals at days 0, 15, 30 and 51 ~ 54. The kinetics of the number of type II pneumocytes were quantified by flow laser cytometry. The following results were recorded:

The number of type II pneumocytes and alveolar macrophages in lung tissue chopper from silica instilled rats result in elevated lung type II pneumocytes. The high peak is on the 15th day after silica instillation. These changes occur with the formation of the early stage silicotic nodules described above. (Paper received 19 November 1984; finalized 20 June 1985.)

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STUDIES OF INDUCTION OF α AND γ INTERFERON IN CHRONIC HEPATITIS B PATIENTS

Beijing ZHONGHUA NEIKE ZAZHI [CHINESE JOURNAL OF INTERNAL MEDICINE] in Chinese Vol 25 No 6, 20 Jun 86 pp 347-349, 381-382

[English abstract of article by Zhang Limin [1728 0448 3046], et al., of Shanghai Jingan Central District Hospital]

[Text] Peripheral blood mononuclear cells of 11 chronic hepatitis B patients and 10 controls were studied for production of α and γ interferons to new Castle Disease virus and concanavalin A. It was found that the titer of the α interferon produced was significantly lower in the chronic hepatitis B patients than in the controls (4.2234 ± 3.9305 versus 7.0411 ± 6.6773), whereas the titer of the γ interferon was similar, or slightly increased, in the patients when compared with that of the controls (5.3074 ± 4.6271 versus 4.4228 ± 3.3637). In any individual patient, there was neither positive nor negative correlation between the production of the two types of interferon. Such data suggests that while the response of B and NK cells was decreased at the induction of interferon, T cells maintained their response to the induction of interferon. (Paper received 10 January 1985; finalized 10 March 1985.)

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NATURAL KILLER ACTIVITY OF PERIPHERAL BLOOD IN PATIENTS WITH APLASTIC ANEMIA

Beijing ZHONGHUA NEIKE ZAZHI [CHINESE JOURNAL OF INTERNAL MEDICINE] in Chinese
Vol 25 No 6, 20 Jun 86 pp 350-352, 382

[English abstract of article by Zhang Ruifa [1728 6904 4099], et al., of Wuhan Overseas Chinese Hospital]

[Text] Using ^{125}IUdR labeled K_{582} cells as target cells, the natural killer cell (NK cell) activity of peripheral blood mononuclear cells was measured in 36 cases of aplastic anemia and 62 healthy volunteers. NK activity in normal individuals and in patients with aplastic anemia was 50.20 ± 17.68 ($\bar{X}$±SD) and 23.66 ± 17.40 respectively. It was found that NK activity in patients with aplastic anemia was significantly lower than in normal individuals ($P < 0.01$). The NK activity in convalescent cases of aplastic anemia (42.74 ± 19.55) was higher than that in untreated or therapeutically ineffective cases ($P < 0.01$). It was shown that NK activity was relevant to the bone marrow cellularity of the patients. It was also found that the mean NK activity in hypercellularity cases was higher than that in hypocellularity cases. In addition, the NK activity in 13 cases of other hematologic disorders was measured, and the results showed that all of them had a lower level of NK activity. The authors conclude that NK activity may be used as an index for evaluating the general condition and hemapoietic function of patients with aplastic anemia. The authors also suggest that the susceptibility of aplastic anemia patients to infection, especially viral infection, is not only due to a decrease in the number of neutral granulocytes, but also to low NK activity. (Paper received 2 February 1985; finalized 12 August 1985.)

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STUDY OF PRIMARY STRUCTURE OF 27 TYPES OF HEMOGLOBIN VARIANTS IN CHINA

Tianjin ZHONGHUA XUEYEXUE ZAZHI [CHINESE JOURNAL OF HEMATOLOGY] in Chinese Vol 7 No 7, 30 Jun 86 pp 322-326, 382

[English abstract of article by Wang Hebi [3769 5440 4310], et al., of the Institute of Hematology, Chinese Academy of Medical Sciences]

[Text] A hemoglobinopathy cooperative group of 22 provinces and cities was organized, and a total of 1,165 probands of abnormal hemoglobin was found among 352,879 individuals. Structural analysis was carried out from 1981 to 1985. The primary structures of 27 variants, including 11 α-chains and 16 β-chains, in 164 families were analyzed. They were all single amino acid substitutes. Four variants (Hb J Zizhong, Hb J Huaxi, Hb J Luhe and Hb G Xuchang) were found for the first time, and eight variants (Hb J Sardegna, Hb J Mexico, Hb Ankara, Hb D Iran, Hb Lufkin, Hb G Szuhu and Hb J Hacettepe) were found for the first time in China. The other variants were identical to those reported earlier. The geographical distribution of seven common variants was as follows: Hb G Coushatta, Hb G Taipei and Hb D Punjab were found predominantly in North China (85.0 percent, 68.0 percent and 100.0 percent respectively), but Hb E, Hb J Bangkok, Hb New York and Hb G Chinese were found mainly in South China (80.0 percent, 77.3 percent, 88.9 percent and 100.0 percent respectively). (Paper received 22 March 1986.)

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MORPHOLOGICAL AND FUNCTIONAL STUDIES OF ERYTHROCYTES IN HEMOGLOBINOPATHIES

Tianjin ZHONGHUA XUEYEXUE ZAZHI [CHINESE JOURNAL OF HEMATOLOGY] in Chinese
Vol 7 No 7, 30 Jun 86 pp 332-334, 383

[English abstract of article by Yang Xueyong [2799 1331 1661], et al., of the Institute of Hematology, Chinese Academy of Medical Sciences]

[Text] The components of hemoglobin were different in α-thalassemia, β-thalassemia and HbE-β thalassemia. There may be different morphological changes also. High density materials and enlarged nucleopores appeared in the erythrocytes of HbE-β thalassemia. Inclusion bodies found in HbH erythrocytes were always attached to cell membranes. Less of bands I and II and deletion of bands III and IV could be found in the membrane protein of the β-thalassemia major erythrocytes and more of band VII could appear in HbH disease. The ratio of cholesterol and phospholipid in β-thalassemia was lower than in the control. The deformibility defects were the characteristics of β-thalassemia and HbH disease. These caused a shortened survival time of HbH erythrocytes and a high death index in the spleen. These findings led to HbH splenectomy benefits. (Paper receiver 24 January 1986; finalized 14 April 1986.)

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TRAPPING OF HYDROGEN BY PRECIPITATE TiC IN LOW CARBON STEEL

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3, 18 Jun 86 pp A181-A188

[English abstract of article by Xian Aiping [0405 1947 1627], et al., of the Institute of Metal Research, Chinese Academy of Sciences, Shenyang]

[Text] The influence of Ti on hydrogen diffusion in low carbon steel has been studied by Davanathan's electrochemical method. The experimental results show that the strong trapping of hydrogen appears in the steel in which the Ti precipitated as dispersed TiC during aging after solution treatment. The trapping energies of the precipitation of dispersed TiC are evaluated as 27.88 ± 0.18 and about 21 kJ/mol respectively before and after the $\alpha \leftrightarrow \gamma$ phase transformation of the steel. However, these do not coincide with the value of 94.55 kJ/mol reported by Pressouyre. The lowest apparent diffusion coefficient of hydrogen in the steel Fe-0.2Ti-0.1C is found after being solution-treated at 1200°C and aged at 550°C. It seems to be caused by the low temperature precipitate TiC with a non-cubic structure and by many lattice vacancies which distort the local periodical potential fields around it. (Paper received 27 May 1985.)

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EFFECT OF HYDROGEN ON YOUNG'S MODULUS AND COHESIVE ENERGY OF Ti-15Mo ALLOY

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3, 18 Jun 86 pp A189-A194

[English abstract of article by Wan Xiaojing [8001 2556 2589], et al., of the Institute of Metal Research, Chinese Academy of Sciences, Shenyang]

[Text] The effect of hydrogen on Young's modulus for β-titanium alloy Ti-15Mo has been investigated by both acoustic resonance and static methods. Results show that Young's modulus is continuously reduced by hydrogen. It seems to not be the result of hydride formation and damage caused by hydrogen charging, and the decrease of the modulus induced by hydrogen and its recovery are entirely reversible. The difference in cohesive energy among the specimens charged with various hydrogen contents has been measured by an ion microprobe mass analyzer. The cohesive energy is found to be significantly lowered by dissolved hydrogen. An explanation of the experimental results may be given by the decohesion theory of hydrogen embrittlement. Young's modulus decrease of the alloy induced by hydrogen may be attributed at least in part to the lowering of cohesive energy of the lattice, and this study may be considered to be a verification of the decohesion theory. (Paper received 22 May 1985.)

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FATIGUE CRACK GROWTH FOR Ti-6Al-4V ALLOY IN WATER

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3, 18 Jun 86 pp A195-A200

[English abstract of article by Gao Shujun [7559 2885 3182], et al., of the Institute of Metal Research, Chinese Academy of Sciences, Shenyang]

[Text] The environmentally assisted fatigue crack growth for annealed Ti-6Al-4V alloy plates in distilled water has been studied using the fracture mechanics method. Fatigue crack growth rates $\frac{da}{dN}$ were determined as a function of stress intensity factor range ΔK from 20 to 45 $MPam^{1/2}$, temperature from 273 to 353 K and frequency from 0.1 to 75 Hz at a load ratio of 0.11. Reference data were obtained in laboratory air at room temperature and a frequency of 10 Hz. Furthermore, SEM fractographic studies have been carried out to observe the fatigue fracture morphologies. The experimental results show that fatigue crack growth in water is enhanced when compared with that in air. The relationship between $\frac{da}{dN}$ and ΔK follows the Paris equation. Fatigue crack growth rates were found to decrease with increasing temperature and to increase with decreasing frequency. The temperature dependence of crack growth rate at a frequency of 10 Hz can be described as: $\frac{da}{dN} = Ae^{Q/RT} (\Delta K)^{2.7}$, where $Q = 6.2$ kJ/mol. the fatigue fracture surface is composed of relatively flat regions and irregular fracture regions. The flat regions are covered with three kinds of fatigue striations: ductile striations, fissure striations and brittle striations. The irregular fracture regions are heavy plastic deformation areas, combined sometimes with small areas of striations. The ductile and fissure striations show an approximate one to one correspondence with the load cycles, whereas the spacing of the brittle striations is several times larger than the corresponding macroscopic growth rate. Enhancement of fatigue crack growth by water is believed to result from embrittlement by hydrogen that is produced by the reaction of water with the crack surface of the Ti alloy. The observed temperature and frequency effects on the fatigue crack growth rate can be explained in terms of a strain-induced hydride mechanism. Formation of strain-induced hydride is considered to be the rate-controlling process for crack growth. (Paper received 22 May 1985.)

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DEPENDENCE OF HYDROGEN CONTENT ON HYDRIDE STRUCTURE AND YIELD STRENGTH OF TITANIUM PLATE

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3, 18 Jun 86 pp A201-A205

[English abstract of article by Wang Ruikun [3769 3843 0981], et al., of Beijing General Research Institute of Non-ferrous Metals]

[Text] The yield strength of pure Ti plate may be decreased at 540-650°C for specimens containing H within the range of 60 to 80 ppm, but it decreases no further with an increase in H. The sharp upper-lower yield point occurs on the stress-strain curve as the H content is less than 50 ppm at room temperature and 540°C, and disappears as H is over 50 ppm or at 650°C. Therefore, the maximum interaction energy between the H atom and dislocation in pure Ti is calculated to be 0.47 - 0.53 eV.

The morphology of hydride in pure Ti has been observed in the plate or needle shape. The hydride TiH_2 was found to be the structure of BCT or fcc as the H content is less or more than 80 ppm respectively. It has also been observed under HVEM that the hydride in specimens containing 15 ppm H is of the BCT structure. (Paper received 3 May 1984; finalized 14 April 1985.)

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INTERNAL FRICTION OF HYDRIDE PRECIPITATION IN Ta-H ALLOYS

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3, 18 Jun 86 pp A206-A212

[English abstract of article by Li Guangyi [2621 1639 5030], et al., of the Institute of Metal Research, Chinese Academy of Sciences, Shenyang]

[Text] The low frequency internal friction of cold-worked Ta wire with high purity was measured before and after hydrogen charging. It showed that a precipitation peak appears at higher temperatures than that of the H-SK peak, and at the same time the latter decreases in height after charging. An additional twist shows a remarkable influence on the precipitation peak. Aging at the temperature at which O atoms are able to migrate to the dislocations might completely eliminate the enhancement effect. The results indicate that the hydrides might preferentially precipitate on the dislocations. The precipitation peak is considered to be associated with the interaction between the dislocations and the hydrides. (Paper received 22 May 1985.)

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IN SITU STUDY OF EFFECT OF HYDROGEN ON DEFORMATION AND FRACTURE BEHAVIOR IN Nb

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3,
18 Jun 86 pp A223-A228

[English abstract of article by Chen Lian [7115 1670], et al., of the Institute of Metal Research, Chinese Academy of Sciences, Shenyang]

[Text] SEM and optical microscope in situ examinations under tensile loading were performed on the effect of hydrogen upon the microprocess of deformation and fracture behavior in cathodic charged pure Nb. The Nb hydrides are found to precipitate on the {100} plane of the matrix. Most dendritic hydrides in orthorhombic needle shape are of the Widmanstatten structure. The slip lines and grain boundary hunches are obviously observed in the α-solid solution matrix with hydrogen dissolved under tensile deformation. The microcracks initiated themselves predominantly along the slip lines and the deformation bands as well as the grain boundary oriented normally to the stress axis. The main crack propagation is the coalescence of microcracks in the vicinity of the crack tip and through the transgranular path. The α-solid solution matrix with β-hydride is extremely brittle and of transgranular cleavage fracture under tension. The micro-patterns, featuring all brittle fractures and two β-hydrides, appear on the cleavage facets. The microcrack growths are present at the hydride/matrix interface. The crystal orientation of hydrogen embrittlement cleavage facets in pure Nb, the stress induced β-hydride and two typical hydrogen embrittlement mechanisms of pure Nb are also discussed. (Paper received 3 September 1984; finalized 4 March 1985.)

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CRYSTALLOGRAPHY OF MARTENSITIC TRANSFORMATION IN Cu-26Zn-4Al SHAPE MEMORY ALLOY

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3,
18 Jun 86 pp A229-A235; A236-A242

[English abstracts of articles by Zhu Weiguang [2612 0251 0342], et al., of Shanghai Jiaotong University]

[Text] I. Experimental and Phenomenological Theory

A study of the crystallography of martensitic transformation in a Cu-26Zn-4Al alloy be means of the phenomenological crystallographic theory is presented. The habit plane of the martensite calculated by a computer from W-L-R theory is found to be $(\bar{1}, 7.71, 9.32)$ through the model of B_2-modified 9R monoclinic structure, which is consistent with that of the experimental results $(\bar{1}, 7, 8)$. (Paper received 15 June 1984).

II. Application of Group Theory

From group theory, the irreducible representation and the 24 variants associated with the martensitic transformation of a Cu-26Zn-4Al alloy are obtained. The self-accomodating group is found to be D_{2h}, and the symmetry in one and the set of self-accomodating groups are analyzed. (Paper received 15 June 1984; finalized 27 October 1985.)

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MÖSSBAUER SPECTROSCOPIC STUDY OF Nd-Fe-B PERMANENT MAGNETIC ALLOY

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3, 18 Jun 86 pp A251-A255

[English abstract of article by Qian Xiangrong [6929 4382 2837], et al., of Shanghai Institute of Iron and Steel Research]

[Text] The permanent magnets of the nominal composition $Nd_xB_yFe_{100-x-y}$, with x=15 or 16 and y=4-10, were investigated by means of the Mössbauer effect. The Mössbauer spectra may be resolved into the subspectra corresponding to the different phases. Mössbauer measurements show that the constituent phases of the alloy vary with its B content. The α-Fe and Nd_2Fe_{17} are observed in the alloy without B; the tetragonal $Nd_2Fe_{14}B$ occurs and Nd_2Fe_{17} disappears in that containing 4 at.-percent B; the Nd-rich and B-rich phases in addition to $Nd_2Fe_{14}B$ exist and α-Fe vanishes in that up to 7 at.-percent B, and the B-rich phase tends to increase predominantly while further increasing the B content. Six subspectra of the tetragonal phase correspond to the six non-equivalent Fe sites. It is pointed out that the j_2 site possesses maximum hyperfine field and also maximum quadruple splitting. The preferential occupation of the j_2 site by Fe atoms is critical for establishing the high anisotropy and remanence. (Paper received 17 December 1984; finalized 2 July 1985.)

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EFFECT OF STRENGTH ON CORROSION FATIGUE BEHAVIOR OF LOW ALLOY STEELS IN ARTIFICIAL SEAWATER

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3, 18 Jun 86 pp A275-A282

[English abstract of article by Zheng Wenlong [6774 2429 7893], et al., of Shanghai Institute of Materials Research; Li Ge [2621 7245], et al., of Shanghai Baoshan Iron and Steel Works]

[Text] The corrosion fatigue (CF) and stress corrosion cracking (SCC) behavior of 34CrNi3Mo and 40CrNiMo steels with different strength grades and given various tempering treatments have been investigated in artificial seawater using fracture mechanics and electrochemical methods. Experimental results show that the SCC susceptibility of the steel in seawater is increased and the CF crack propagation rate, da/dN, is sharply raised with the increase of its YS. For steels of YS over 890 MPa, tempered less than 650°C, the da/dN vs ΔK plot appears as a plateau, in which the $(\frac{dN}{da})_{II}$ is almost constant and its fracture surface is similar in shape to that of SCC. It is believed that the CF behavior is closely related to the SCC, and the SCC susceptibility of the steel is promoted under the CF condition. (Paper received 3 September 1984; finalized 4 March 1985.)

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EXAFS MEASUREMENT OF METALLIC GLASS $Cu_{70}Ti_{30}$ ATOMIC NEIGHBORING STRUCTURE

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3,
18 Jun 86 pp B105-B110

[English abstract of article by Chang Longcun [1603 7893 1317], et al., of the Institute of Physics, Chinese Academy of Sciences, Beijing]

[Text] Copper K edge EXAFS spectrum of the metallic glass $Cu_{70}Ti_{30}$ has been measured using the RU-1000 rotating anode X-ray system with a goniometer. Data analysis has been processed based on the EXAFS analysis program package written in the authors' laboratory. The distances, coordination numbers and Debye-Waller factors between the Cu atoms and neighboring atoms are determined by fitting the experimental data with the theoretical phase and backscattering amplitude. The chemical short range order and atomic neighboring structure feature of the metallic glass $Cu_{70}Ti_{30}$ are discussed. (Paper received 28 August 1984.)

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FRACTURE BEHAVIOR OF FUSED QUARTZ PARTICULATE COMPOSITES

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22 No 3, 18 Jun 86 pp B111-B117

[English abstract of article by Wang Runze [3769 3387 3419], et al., of Luoyang Institute of Refractory Research]

[Text] The fracture behavior of the fused quartz particulate composites has been investigated. It shows that the volume fraction of particles dispersed in the matrix leads to direct dependencies of the elastic modulus and fracture surface energy, inverse changes in bending strength as well as increasing in an exponential relationship with fracture work and thermal shock damage resistance parameters. The decohesion of the weak interface between the particle and matrix may be considered to be the origin of toughening. (Paper received 25 June 1984.)

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CSO: 4009/1002

125-IODINE-LABELLED SECOND ANTIBODY SEPARATION RATIOIMMUNOASSAY FOR CYCLIC GMP

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 10, Oct 86 pp 54-56, back inside cover

[English abstract of article by Fang Jun [2455 6511], et al., of Shanghai Chinese Medical College, and Wu Baihui [0702 0130 1920], et al., of Shanghai Institute of Chemical Reagents]

[Text] This paper describes iodine labelled radioimmunoassay for the cyclic GMP. Preparations of antigen, antibody and radioligand are described. A second antibody separation of simple high sensitivity method for the assay of cyclic GMP is presented.

The cross-reactivity of this cyclid GMP antiserum with cyclic AMP and GTP are 0.008 percent and 3.1×10^{-3} percent respectively.

Sensitivity of the method is 1.5 fmol cyclic GMP per tube. Recovery of the method is 104.0±4.7 percent and variety coefficient in batch is 2.8 percent.

Cyclic GMP content in the plasma of normal man is 4.60±0.70 pmol/ml. (Paper received 28 Oct 85.)

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CSO: 4009/3006

FINE STRUCTURE OF MAGNETIC MODES EXCITED IN YIG FILMS

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 8, Aug 86 pp 1072-1076

[English abstract of article by Zhang Pengxiang [1728 7720 5046], Hong Tao [3163 3447] and Cao Keding [2580 0344 1353] of the Institute of Physics, Chinese Academy of Sciences]

[Text] A series of magnetic modes was observed in LPE YIG films magnetized in a plane. These magnetic modes were excited by means of magnetostatic wave excitation and showed characteristics of equal spacing and slower attenuation than normal standing spin waves. Considering that the precession is elliptical and supposing there is inhomogeneity of magnetization in the film, the authors deduce a relationship between mode spacing and the magnetic parameters of YIG. Compared with experimental results, an inhomogeneity of 2.6-5.8 percent was deduced for the LPE YIG films.

SUPERCONDUCTIVITY OF TWO-DIMENSIONAL GRANULAR FILMS

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 8, Aug 86
pp 1081-1086

[English abstract of article by Wang Wei [3769 3555], et al., of the Department of Physics, Nanjing University]

[Text] The authors measured the R-T characterization of various Sn granular film samples at low temperatures. The samples were prepared using the thermovaporization method in a vacuum chamber containing oxygen.

Because of the grains and grain sizes, and the distances between the grains are randomly distributed, the Josephson coupling and thermal excited electrons of the hopping process between the grains are not identical for different samples. Therefore, the experimental results may be recognized as the following three kinds of processes: (1) transition to zero resistance; (2) minimum resistance; and (3) metal-insulator transition.

ELECTRON MICROSCOPY STUDIES ON INTERACTION BETWEEN CREEP AND FATIGUE

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 35 No 8, Aug 86 pp 1091-1094

[English abstract of article by Kong Qingping [1313 1987 1627], Wang Xiang [3769 5046], Zhou Hao [0719 3185] and Ni Qunhui [0242 5028 1979] of the Institute of Solid State Physics, Chinese Academy of Sciences, Hefei]

[Text] The mechanism of creep-fatigue interaction in a nickel base alloy (Nimonic 75 type) has been studied by transmission and scanning electron microscopy.

Experiments at 873 K and a stress amplitude of 392 MPa showed that the data of creep, fatigue and "creep combined with fatigue" obeyed approximately the linear cumulative law. Micrographs of fracture surfaces by SEM indicated that the rupture was intergranular. However, observations by TEM showed that the dislocation configurations within fractured specimens were quite different among creep, fatigue and "creep combined with fatigue." The authors believe that different dislocation configurations have different influences on the process of intergranular rupture, and the damages due to creep and fatigue are independent of each other. Consequently, linear interaction between creep and fatigue occurs macroscopically.

The present paper shows that TEM has great potential for revealing the mechanism of creep-fatigue interaction.

STUDY OF INSTABILITY OF BISTABLE INJECTION LASERS

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[English abstract of article by Wang Shouwu [3769 1343 2976], Wang Qiming [3769 0796 2494] and Lin Shiming [2651 0013 7686] of the Institute of Semiconductors, Chinese Academy of Sciences]

[Text] The theory of instability for non-linear differential equations is applied to the rate equations of a bistable laser. It is found that there are three conditions that must be fulfilled in order for the system to be made stable. The first condition is automatically fulfilled in ordinary bistable lasers. The second and third conditions are related to the self-pulsation and bistable characteristics of the laser respectively. It has been shown that if the third condition is not fulfilled in a certain region, the linearized rate equation for a small-signal will have a monotonously increasing solution in that region. This means that the light power output curve has a negative slope region, which would result in a bistable character. On the other hand, if the second condition is not fulfilled, the linearized rate equation for the small-signal will have enhanced oscillating solutions. This means that the laser will self-oscillate as long as the third condition is fulfilled in that region. In addition, it is also shown that both the self-pulsation and the bistable behaviors of the laser are closely related to the non-linearity of the f(N) function, which is the necessary condition for having a linearized rate equation of the third order.

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